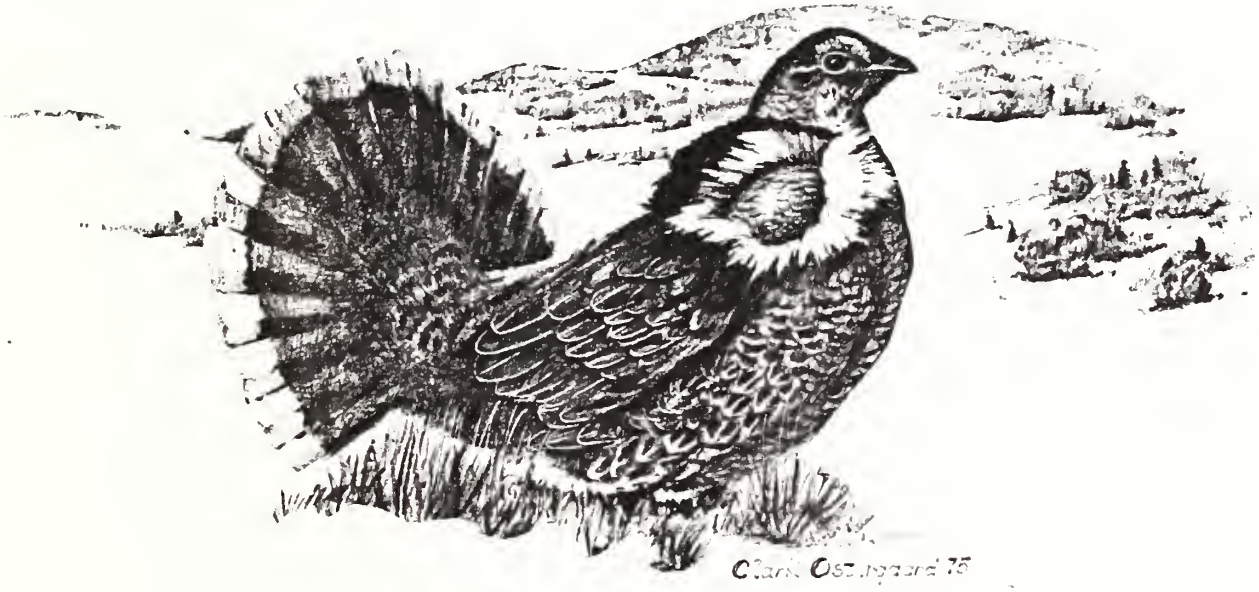
Blue Grouse Ecology

Habitat Requirements and Response to Habitat Manipulation in North Central Utah



Wasatch National Forest
U.S.D.A. Forest Service, Region 4

BLUE GROUSE ECOLOGY, HABITAT REQUIREMENTS, AND RESPONSE TO HABITAT MANIPULATION IN NORTH CENTRAL UTAH

BY

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INTRODUCTION

The blue grouse (Dendragapus obscurus) is a common resident of the mountainous forest country of western North America. It is important as a game bird over much of its range, and is of particular interest because of its colorful mating displays and unusual "reversed" migration. Blue grouse usually move to higher elevations in the fall, spend the winter there, and return to lower areas in the spring to breed and raise their young. Good blue grouse populations presently inhabit the Wasatch National Forest of northern Utah and southern Idaho.

Previously, little was known of the life history or specific habitat requirements of blue grouse in Utah. Because of this lack of basic information, it was not possible to consider the effects of various land uses upon blue grouse when formulating management plans. One objective of this study was to obtain basic data concerning blue grouse in Utah. A second objective was to study the effects of herbicidal spraying upon a blue grouse population.

Herbicidal spraying to remove or reduce certain plants, most commonly sagebrush, is a frequently used habitat manipulation technique in the western United States. Since little, if anything was known about the effects of herbicidally induced vegetational changes upon blue grouse, the U.S. Forest Service initiated this study in 1970.

The study area was to be sprayed with 2,4-D herbicide in 1972 in order to reduce the density of a large stand of mule ears (Wyethia amplexicaulis) and create a better vegetational composition for grazing and watershed purposes. The study was begun in 1970 to obtain pre-spraying data on blue grouse habits, vegetative composition, and insect numbers and species present. David A. Weber, a graduate student in Wildlife Science at Utah State University, began field studies in May 1970, working through the Utah Cooperative Wildlife Research Unit under the direction of Dr. J. B. Low. In 1971, T. Barry Barnes, also a graduate student in Wildlife Science at Utah State University, joined Weber on the study. Data gathered in 1970 and 1971 were reported by Weber (1972). Barnes and undergraduate student Greg Rost continued field work during 1972. Portions of the study area were sprayed with a 2,4-D herbicide solution by helicopter on June 2, 1972. In 1973, David Weber evaluated the effects of the 1972 treatment. It became apparent in the spring of 1973 that the 1972 spray had not been effective in killing the mule ears because an experimental invert water-in-oil emulsion technique was used in order to reduce spray drift and reduce evaporation, although it had effectively reduced sagebrush, thus, the decision was made to respray the area, which was done between June 19 and 25, 1973, using a tractor-pulled ground sprayer. Results of the study through 1973 were summarized by Weber (1973). Vann Covington, an undergraduate student in Zoology at Utah State University, continued the field work in 1974 to evaluate the short-term effects of the treatment on grouse. His report (Covington and Weber 1973) was submitted in November 1974. The purpose of the present report is to summarize the findings of the project from 1970

through 1974, and to make recommendations concerning land use practices in blue grouse habitats. A followup study will be made in the late 1970's to monitor long-term effects, if any, of vegetational changes upon blue grouse.

This project was accomplished in close cooperation with and partially funded by the Utah Cooperative Wildlife Research Unit under the direction of Dr. J. B. Low. Utah State University and the Utah Division of Wildlife Resources also cooperated. U.S. Forest Service personnel involved in the study were Bruce Reese, Craig Whittikiend, and especially Frank Gunnell, whose assistance was invaluable throughout the project. Jack Rensel, Clair Huff, and John Kimball of the Utah Division of Wildlife Resources provided equipment and advice during the study, and aided in obtaining collecting permits and gathering band return information.

STUDY AREA

The study area was located 23 miles south of Logan, Cache County, Utah (Figure 1). A semi-improved road, Utah Rt. 162, bisected the area. The study area was within sections 20, 21, 28, and 29; T.8N., R.1E. Most of the area was part of the Wasatch National Forest, but the eastern edge was on privately owned lands.

Most of the research on breeding, nesting, and brood rearing, as well as vegetation and insect studies, was done on a 814-acre tract of rolling to hilly terrain. Some minor investigations of possible wintering areas, migration routes, and food habit collections were made off the study area. Elevations on the study area varied from 6,200 to 6,600 feet above sea level. James Peak, a 9400-foot high mountain, was just to the east of the area, and a ridge rising to 7,300 feet bordered the area on the west.

Dominant vegetation during spring and summer was mule ears, black sagebrush (Artemisia nova), and big sagebursh (A. tridentata). The two types of sagebrush on the study area were identified as A. nova and A. tridentata in 1970 by Professor Arthur Holmgren, Director of the herbarium at Utah State University. However, low-growing sagebrush samples from the area were examined by U.S. Forest Service personnel, utilizing the ultra-violet light technique developed by Winward and Tisdale (1969). All samples from the area exhibited "flouresce shades of bluish-cream," wereas A. nova should exhibit floursece shades of brownish-red. The high-growing sagebrush also was classified as A. tridentata vasianna. Thus, there presently is disagreement as to the classification of sagebrush on the study area. The most notable difference between the two species was that A. tridentata was mostly 2-3.5 feet in height, while A. nova (?) seldom grew higher than 18 inches.

Many grasses were present, the most common being various species of needlegrass (Stipa spp.), bluegrasses (Poa spp.), and wheatgrasses (Agropyron spp.). The most common forbs on the area were: wild onion (Allium sp.), lupine (Lupinus sp.), yarrow (Achillea millefolium), tarweed

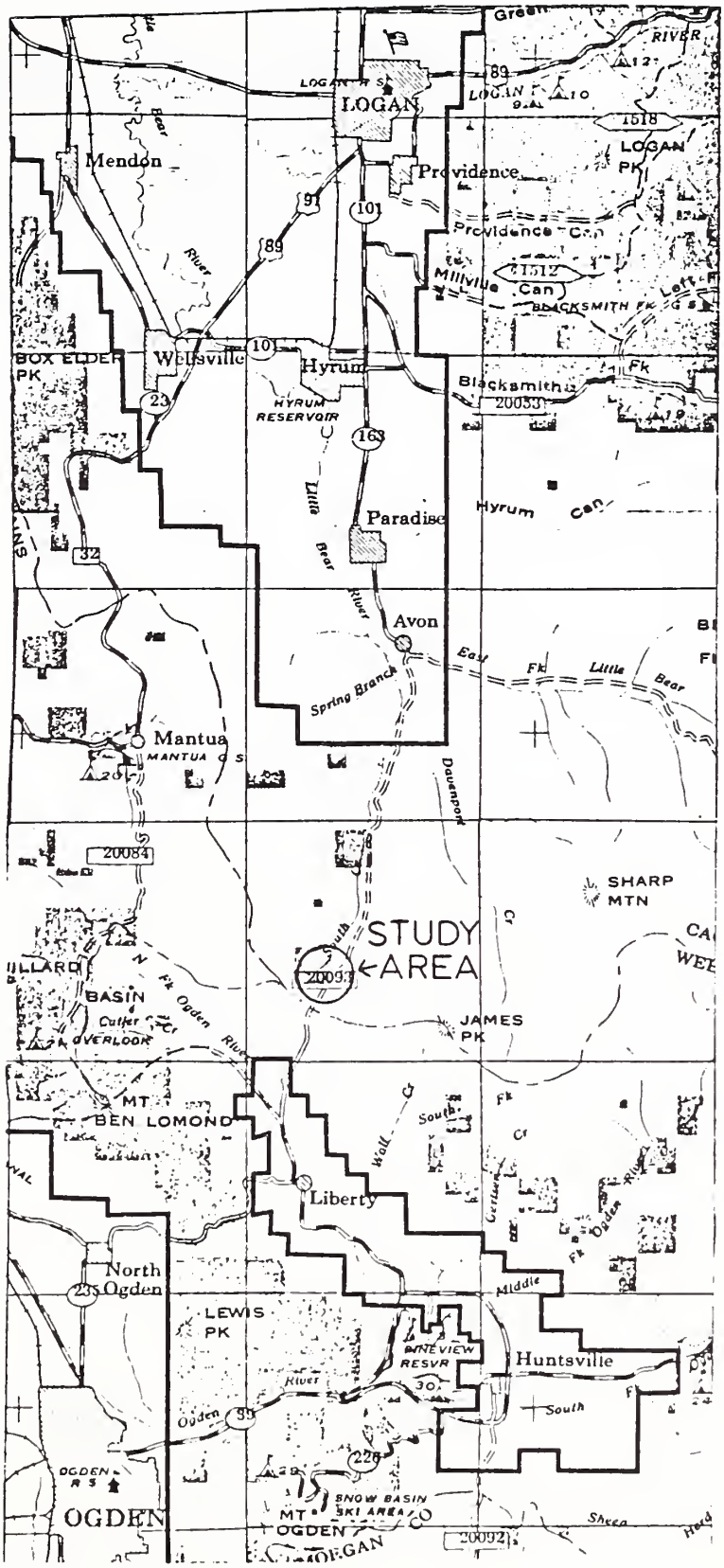

Figure 1. General location of the blue grouse study area in Cache County, Utah.

(Madia glomerata), knotweed (Polygonum douglasii), microseris (Microseris nutans), and ground smoke (Gayophytum diffusum). Some ephemeral forbs, which appeared in the spring but soon disappeared, were: sagebrush buttercup (Ranunculus jovis), collinsia (Collinsia parviflora), spring beauty (Claytonia lanceolata), groundsel (Senecio sp.), and false mermaid (Floerkea proserpinacoides).

Tree species, present as islands on the study area proper and as stands on the surrounding hillsides, were: quaking aspen (Populus tremuloides), Rocky Mountain juniper (Juniperus scopulorum), curlleaf mahogany (Cercocarpus ledifolis), bigtooth maple (Acer grandidentatum), and Gambel's oak (Quercus gambelii). Stands of Douglas fir (Pseudotsuga menziesii) were found at higher elevations on slopes surrounding the study area. The most common shrub species (other than sagebrush) were chokecherry (Prunus virginianus), snowberry (Symphoricarpos oreophilus), and wild rose (Rosa woodsii).

A wide variety of birds and mammals were present on the study area during the spring and summer. Birds which nested on the area included: Brewer's blackbird (Euphagus cyanocephalus), mourning dove (Zenaidura macroura), vesper sparrow (Pooecetes gramineus), killdeer (Charadruis vociferus), common snipe (Capella gallinago), red-shafted flicker (Colaptes cafer), sage grouse (Centrocercus urophasianus), mallard (Anas platyrhynchos), robin (Turdus migratorius), and kestrel (Falco sparvarius). Several species of hawks were observed on the area, as were golden eagles (Aquila chrysaetos). Ruffed grouse (Bonasa umbellus) were early spring and fall visitors to the area.

Mammals common to the area were: northern pocket gopher (Thomomys talpoides), deer mouse (Peromyscus maniculatus), porcupine (Erethizon dorsatum), striped skink (Mephitus mephitus), yellow-bellied marmot (Marmota flaviventris), whitetail jackrabbit (Lepus townsendi), cottontail (Sylvilagus sp.), mule deer (Odocoileus hemionus), coyote (Canis latrans), and various species of chipmunks and squirrels. Leopard frogs (Rana pipiens) were common along waterways, and salamanders were present in some of the cattle ponds on the area.

Numerous small streams, springs, and seeps provided the area with water well into the summer. The largest spring was the origin of the south fork of the Little Bear River.

The area was important mainly as a watershed and recreational area at the time of this study. It was used heavily during the spring and summer by campers, sightseers, motorbikers, and 4-wheel drive vehicle enthusiasts. The area sustained much abuse from off-road vehicle use during the course of the study. Deep ruts were cut into previously undisturbed soils and at least two new "roads" were begun. The area was hunted in the fall, mainly for grouse, and was heavily used by snowmobilers from the Ogden area in winter. The privately owned land to the east was extensively grazed by sheep each summer. Cattle wandering from nearby grazing allotments commonly appeared on the study area.

Summer weather on the study area was mild. Summer daytime temperatures seldom rose above the 80's and usually dropped to the 40's at night. Summer precipitation was low; inclement weather almost never occurred for more than one day at a time. Occasional showers were caused by clouds rising rapidly over nearby James Peak. In most years, the area was under snow cover from late November to April. Snow depths were 3 to 4 feet over most of the area in late winter. In 1973, the area sustained a late, heavy snowfall and resultant late snowmelt. During 1970-72, most snow was gone from the study area by mid-April. In 1973, a foot of snow still remained on much of the area during the first week of May. Snowmelt was again late in 1974, although not as late as in 1973.

The general topography and vegetation types on the study area are shown in Figures 2 and 3. Figure 4 shows a dense stand of mule ears before spraying. The primary reason for the herbicide treatment was to break up such dense stands. These three photos were taken prior to herbicide treatment.

STUDY DESIGN

In order to meet the study's goals of evaluating the effects of herbicidal spraying and gathering information on blue grouse ecology and habitat requirements, several areas of investigation were delineated. These were:

1) To locate male territories, determine their size, and observe breeding behavior.

2) To locate blue grouse nests and report on their location, contents, and behavior of the nesting female.

3) To determine the areas frequented by broods, vegetation types most frequently used, extent of movements, food habits of the young, and observe brood behavior.

4) To determine the numbers of territorial males present before and after herbicidal spraying and the number of broods present before and after spraying.

5) To determine the time of migration onto and off of the study area and, if possible, determine the location of wintering areas.

6) To monitor effects of the herbicidal spraying on the study area vegetation and insect life.

7) To investigate factors affecting grouse mortality.

8) To observe the effects of grazing and human disturbances on the blue grouse and their habitat.

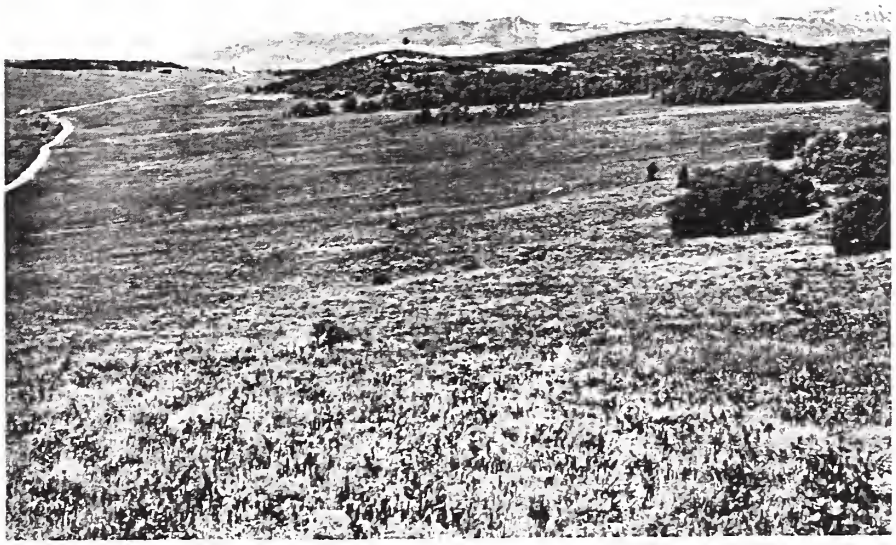

Figure 2. A view showing general topography and vegetation types on the study area. (Photo by Dr. J. B. Low)

Figure 3. The center of the study area. The aspen grove in the left background was heavily used by blue grouse. (Photo by Dr. J. B. Low)

Figure 4. A dense stand of mule ears prior to 2-4 D spraying. (Photo by Dr. J. B. Low)

In order to maintain a control on the herbicidal spraying experiment, 144 acres of the 814-acre study area was left unsprayed (Figure 5). It should be noted that only the non-wooded portions of the spray area were actually sprayed. Thus, the treated area was considerably less than 670 acres.

METHODS

Methods were described in detail in previous reports (Weber 1972 nad 1973). Therefore, only an abbreviated version is presented here.

Male territories. Three methods were used to locate territorial male blue grouse. First, searching was conducted on foot, snowshoe, or horseback until a male was flushed. Dogs usually were used during these searches. Locations of males flushed were plotted on aerial photographs. Repeated flushing of a male from a location was taken as an indication of a possible territory.

The second method, originally described by Stirling and Bendell (1966), involved the use of a recorded female blue grouse call. When played near a male territory, the call occasionally induced males to leave cover and walk into the open in breeding display. This allowed the bird to be observed and located more easily. However, success with this method was inconsistent.

It was discovered by the 1974 field season that the best method for locating territorial males was by listening for vocal "hoots" and "wing rips" in the early morning and evening hours. The peak of audible activity was determined to be from a half hour before sunrise to a half hour after sunrise. Evening listening periods were less productive, but worthwhile.

Searches for territorial males were carried out from mid-May through June in 1970, late March through June in 1971-73, and early May through June in 1974. Efforts were made to capture and mark territorial males throughout the study, but these were not successful because of the wariness of the grouse.

Nests. Searches for nests were conducted from May through June during each year of the study. Searches often were conducted in conjunction with searches for male territories or broods. The search method consisted of walking or riding horseback through possible nesting areas in hopes of either flushing a nesting female or seeing the eggs in an uncovered nest. Dogs usually were used and helped discover several nests which would not have been located without canine assistance. Nests proved very difficult to locate, because of the well-hidden locations chosen by the hens and because hens held tightly to the nests. When a nest was located, pertinent information regarding the nesting site was recorded.

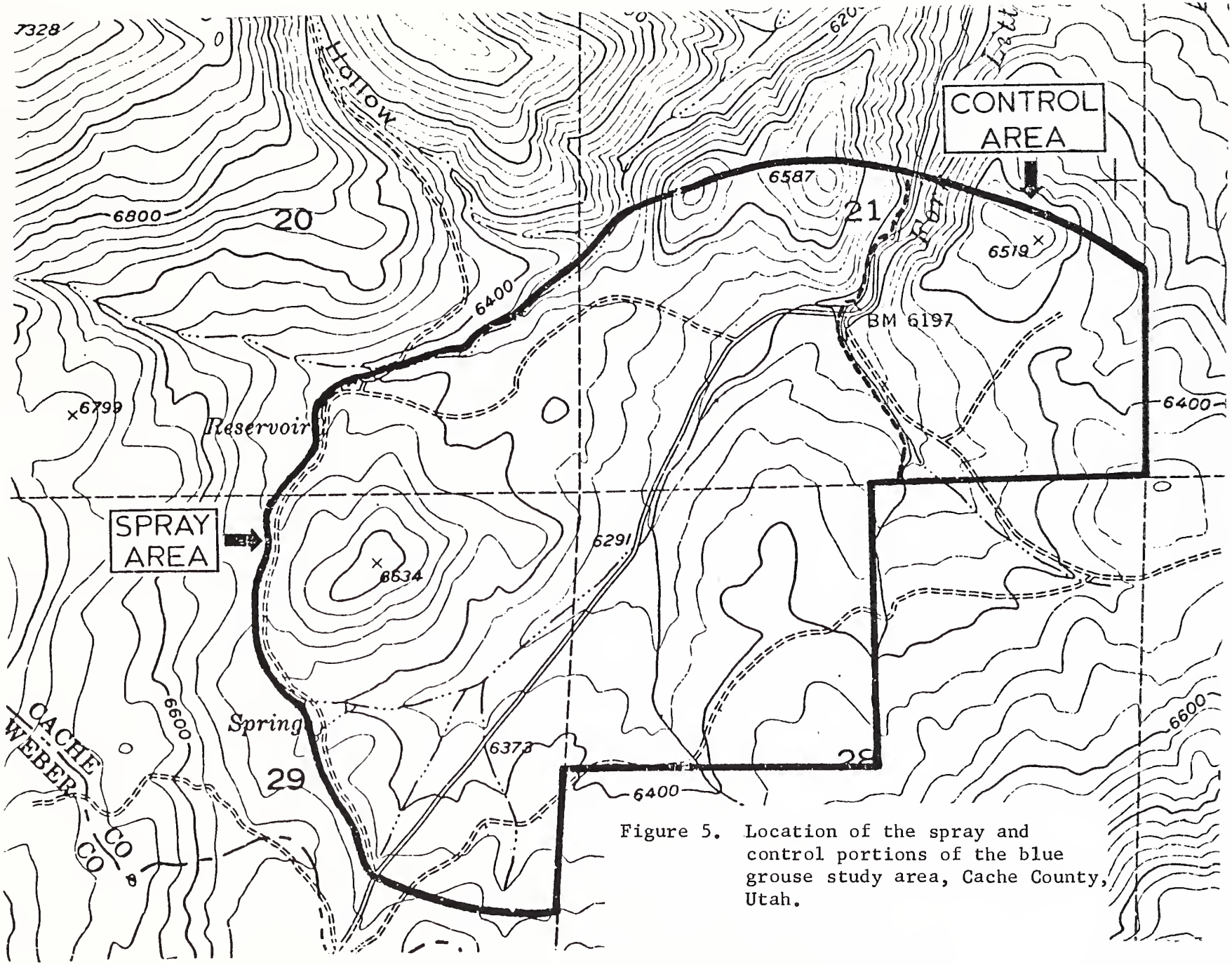

Figure 5. Location of the spray and control portions of the blue grouse study area, Cache County, Utah.

Broods. Searches for broods were made from mid-June until August during each year of the study. Searching on foot or horseback, using dogs, was the method used. As in the case of nests, dogs were invaluable in locating broods which would have been missed by a man alone. When a brood was located, an attempt was made to obtain an accurate count of the chicks. Chicks were captured either by hand or the noosing pole technique described by Zwickel and Bendell (1967) and illustrated in Figure 6. A 15- or 20-foot-long pole was used. The captured chicks were tagged, using colored vinyl streamers, safety-pinned through the skin at the nape of the neck. Chicks which were large enough to hold bands were banded with aluminum leg bands obtained from the Utah Division of Wildlife Resources. Colored plastic tape was placed on the tail feathers of some of the older chicks. This showed up well in flight and allowed for identification of tagged chicks at a distance. Blood smears were taken from 10 of the juvenile grouse captured during 1971 to check for blood diseases.

The location of each brood flushed was recorded, along with a description of the vegetation and topography. Observations of brood behavior also were recorded.

Some juvenile grouse were shot and their crops collected and the contents analyzed each year, except 1974, in order to study their food habits. Two crops also were collected in 1974 from grouse killed by dogs. Groups of food items were separated and the volume of each determined by water displacement, using a graduated cylinder.

Brood movements were determined from re-sightings of previously color-marked young. Distances were calculated by marking the original capture location on a map and measuring the distance from that point to the point at which the re-sighting was made.

Migration. The timing of migration onto and off the study area was determined by noting when blue grouse first were observed on the study area in the spring and when numbers on the area decreased in the late summer and fall. Early spring snowshoe and snowmobile searches confirmed the fact that blue grouse did not winter on the study area.

Direction of migration was determined through the return of bands by hunters who had shot grouse banded on the study area during the late September hunting season. When a band was returned, the hunter was sent a letter which informed him where the bird was banded and asked him to mark the location of his kill on a map of the study area and surrounding vicinity. Snowmobile and foot searches were made to the east and west of the study area to locate winter areas or to flush tagged grouse.

Populations. The number of territorial males on the study area was determined each year by locating the territories and plotting each on a map. Improvements in methods for locating territories were reflected by higher numbers of territories or possible territories located in the later years of the study.

Figure 6. Technique for capturing adult and juvenile blue grouse. A noose at the end of the pole is slipped around the neck of the grouse. (Photo by Dr. J. B. Low)

Because of the mobility of the broods, determining their numbers was more of a problem than that of locating territories. A fair estimate of brood numbers was obtained through intensive searching between mid-June and the end of July. Broods often were recognized by the area they frequented, number of chicks, and size of the chicks. The main purpose of color-marking chicks, however, was to aid in brood recognition. By resighting a color-marked chick when a brood was flushed, it was possible to distinguish broods. By keeping records of where broods were sighted and detailed descriptions of broods, it was possible to estimate brood numbers at the end of the field season. Work on determining brood numbers was concentrated in the June-July period, because chicks then were smaller and broods less mobile. In addition, it was found that by the end of July and during August broods began to congregate and feed together, making individual brood identification impossible.

Vegetation. In order to continuously monitor changes in vegetation on the study area, six line transects were established. The transects were placed so that representative samples of both the spray and control portions of the study area were obtained. All transects were placed in the open mule ears-sagebrush flats, rather than through wooded portions of the study area, because only the non-forested portions were to be treated with herbicides (Figure 7). Two 400-yard long transects were established on the control area and four on the treatment areas.

Vegetation along the transect lines was sampled by the method developed by Daubenmire (1959). A 20 x 50 cm metal frame was placed on the ground along the transect line at 10 -yard intervals. The observer then estimated the percent canopy coverage of each plant species within the frame. Rather than estimating exact percentages, six percentage classes (0-5%, 6-25%, 26-50%, 51-75%, 76-95% and 96-100%) were used. A percentage class was determined for each species present, as well as for litter, rock, and bare ground (Table 1). Forty readings were taken on each transect and a mean percent canopy coverage for each plant species was computed by averaging the percentage class readings for each species.

Plant transects were read three times each year from 1971 through 1974. In 1971 and 1972, the transects were read during the first three days of May, June, and July. Because of late snow melts in 1973 and 1974, which caused delayed plant growth, transect readings were delayed in order to try to duplicate the plant phenology during the previous two years' readings.

Insects. Analyses of insect populations were divided into three components: 1) collection and classification of small insects during the period just after the peak of hatching for blue grouse; 2) determination of the number of grasshoppers on the study area during August; and 3) monitoring of changes in the activity of mound ants.

Small insects were collected during the period immediately following the peak of blue grouse hatch, because young grouse extensively depend upon small insects for food during this period. It was felt that during

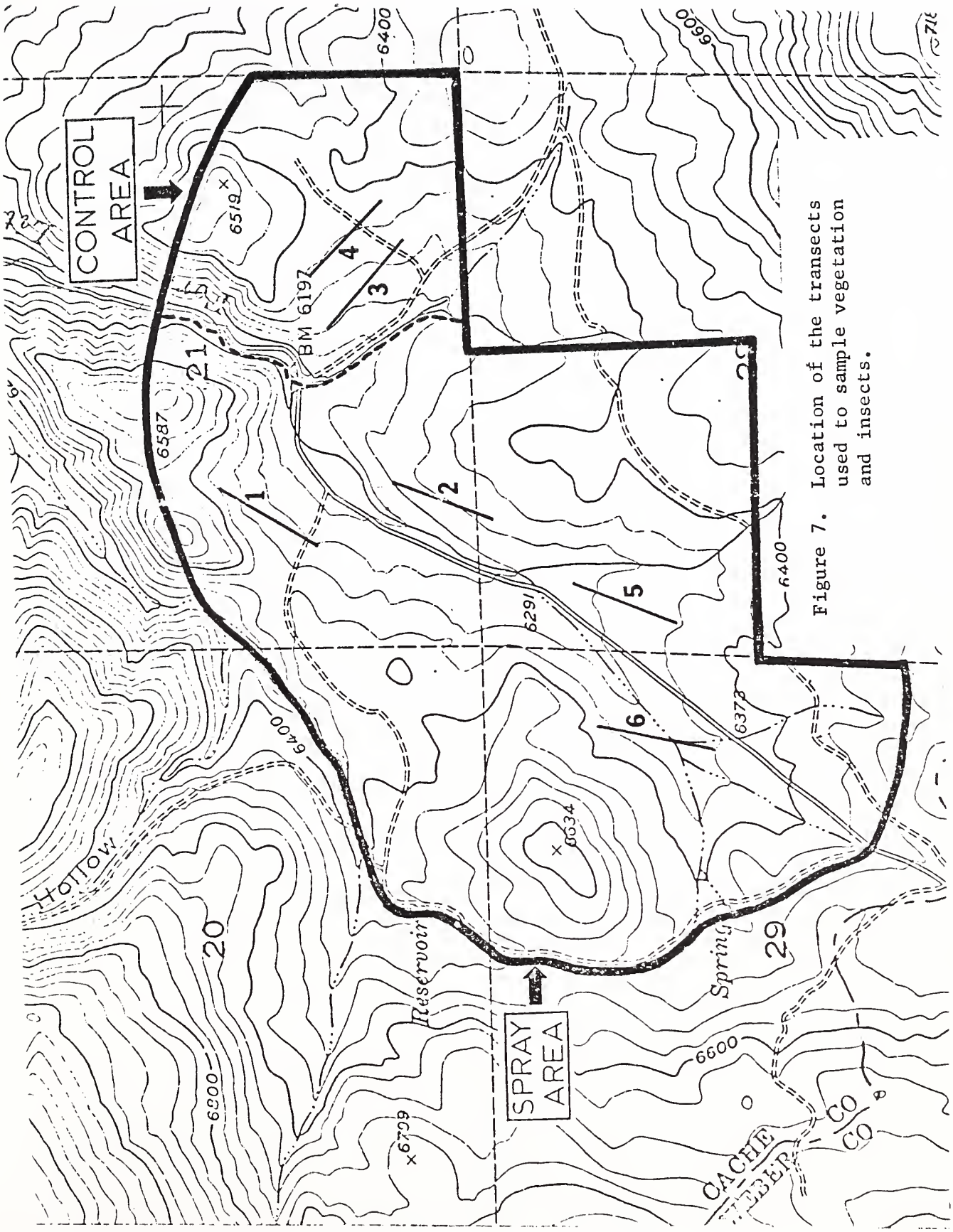

Figure 7. Location of the transects used to sample vegetation and insects.

Table 1. Record of blue grouse banded or color-marked on the study area, 1970-74.

DATE CAPTURED	AGE	SEX	BAND NO.	OTHER MARKS
7-29-70	8 wks.	U[a]	FG-1700	None
7-31-70	10 wks.	U	FG-1699	None
7-31-70	7 wks.	U	FG-1698	None
8-05-70	8 wks.	U	FG-1697	None
8-07-70	8 wks.	U	FG-1696	Yellow Neck Tag
8-12-70	9 wks.	U	Shot by hunter - Sept. 23, 1972	
8-12-70	7 wks.	U	FG-1694	Red Neck Tag
8-12-70	7 wks.	U	FG-1693	Blue Neck Tag
8-12-70	7 wks.	U	FG-1691	Green Neck Tag
8-12-70	Adult	F	Died after being noosed	
8-26-70	10 wks.	M	FG-1692	Yellow-White Neck Tag
8-26-70	10 wks.	M	FG-1690	Red-White Neck Tag
8-26-70	10 wks.	M	FG-1689	Yellow-Red Neck Tag
9-09-70	10 wks.	F	Shot by hunter -	
9-09-70	11 wks.	F	Shot by hunter -	
5-26-71	Yearling	M	Shot by hunter - Sept. 23, 1972	
6-09-71	Yearling	F	FG-1684 A31383	White Poncho "4"
7-07-71	4 wks.	U	None	Yellow Neck Tag
7-08-71	4 wks.	U	FG-1685 A31225	Red Neck Tag
7-13-71	5 wks.	U	FG-1608 A31407 A31348	Yellow-Blue Neck Tag
7-13-71	5 wks.	U	FG-1602 A31326 A31403	Yellow-Blue Neck Tag
7-19-71	5 wks.	U	A31374	Red-White Neck Tag
7-22-71	5 wks.	U	Shot by hunter - Sept. 25, 1971	
7-27-71	6 wks.	U	Shot by hunter - Sept. 25, 1971	
7-27-71	7 wks.	U	FG-1606 A31313 A31402	White Neck Tag
7-27-71	8 wks.	U	FG-1604 A31405 A31385	White-Blue Neck Tag
7-27-71	6 wks.	U	FG-1607 A31408 A 31317	Red Neck Tag
7-27-71	6 wks.	U	Died after being noosed	
7-28-71	8 wks.	U	FG-1605 A31401 A31373	Yellow-Red Neck Tag
7-16-71	5 wks.	U	None	Yellow-Red Neck Tag

Table 1. cont.

DATE CAPTURED	AGE	SEX	BAND NO.	OTHER MARKS
8-11-71	7 wks.	U	FG-1617 A31253 A31401	Blue Neck Tag
5-11-72	Yearling	F	FG-1611 A31414 A31276	Yellow Poncho
7-25-72	Chick	U	FG-1610 A31207 A31417	Yellow-Green Neck Tag
7-26-72	Chick	U	FG-1678	Yellow-Blue Neck Tag
7-26-72	Chick	U	FG-1613 A31275 A31411	Green-White Neck Tag
7-26-72	Chick	U	FG-1682	White-Green Neck Tag
8-07-72	Chick	U	FG-1667	None
8-03-72	Chick	U	FG-1676	Green-Blue Neck Tag
8-07-72	Chick	U	FG-1615 A31410 A31202	Yellow-Green-Red Neck Tag
7-20-72	Chick	U	FG-1616 A31416 A31247	Red Neck Tag
7-27-72	Adult	F	FG-1675	White Poncho "1"
7-27-72	Chick	U	FG-1677	White-Yellow Neck Tag
6-20-73	1 wk.	U	None	Orange Neck Tag
6-20-73	1 wk.	U	None	Lt. Green Neck Tag
6-20-73	1 day	U	None	White Neck Tag
6-20-73	1 day	U	None	Blue Neck Tag
6-20-73	1 day	U	None	Yellow Neck Tag
7-03-73	3 wks.	U	None	Blue-Red Neck Tag
7-03-73	3 wks.	U	None	Blue-Red Neck Tag
7-05-73	3 wks.	U	None	Yellow-Red Neck Tag
7-10-73	2 wks.	U	None	Orange-Blue Neck Tag
7-10-73	2 wks.	U	None	Lt. Green-Red Neck Tag
7-27-73	5 wks.	M	Died after being noosed	
7-30-73	5 wks.	U	FG-1664	Blue White Neck Tag
8-02-73	Chick	U	FG-1665	Green-Red Neck Tag
8-02-73	Chick	U	FG-1662	Green-Red Neck Tag
8-03-73	Chick	U	FG-1660	Blue-White Neck Tag
7-01-74	5 wks.	U	Killed by dog	
7-13-74	7 wks.	U	Killed by dog	
7-15-74	7-8 wks.	U	FG-1633	Red on White Neck Tag
7-22-74	4 wks.	U	None	Yellow Neck Tag
7-25-74	5 wks.	U	None	White Neck Tag

Table 1. cont.

DATE CAPTURED	AGE	SEX	BAND NO.	OTHER MARKS
7-26-74	10-11 wks.	U	FG-1628	Blue on White Neck Tag
7-29-74	Adult	F	FG-1926	Blue, White, Red Neck Tag
7-30-74	11+ wks.	U	Killed by dog	
8-02-74	6 wks.	U	FG-1624	Blue Neck Tag
8-05-74	11+ wks.	U	FG-1625	Yellow Neck Tag
8-05-74	11+ wks.	U	FG-1623	White Neck Tag
8-05-74	8 wks.	U	FG-1622	Red Neck Tag
8-06-74	11+ wks.	U	FG-1631	Red Poncho
5-29-74	Adult or Yearling	F	FG-1654	White Poncho X
6-04-74	Yearling	F	FG-1656	Fluorescent Red Poncho
6-04-74	Adult or Yearling	F	FG-1657	Fluorescent Red Poncho
	Sage Grouse (wing broken during noosing)			
6-04-74	Adult	F	FG-1659	White Poncho

Note: The female blue grouse (FG-1659) was captured off her nest, which was located about 1/4 mile NW of Porcupine Reservoir under a sagebrush bush.

[a] U=unknown sex, F=female, M=male

this time the most insects important in the diet of young grouse would be sampled. Sampling was done along the same transects used for vegetation analyses. A vacuum pump, which pulled insects and debris into an extendable funnel opening and a net, was used to collect insects. The funnel opening was one square foot in size. Eight samples were taken at 50-yard intervals along each of the six transects. A sample consisted of the insects collected by placing the funnel on the ground 10 times for 2 seconds in a semi-circle in front of the sampler. The samples were removed from the net and placed in a plastic bag after each sampling. Samples then were frozen until examination. In the laboratory, the insects were removed from the litter, grouped by species, counted, oven dried, and the total sample weighed. The average number of insects from each group on each transect was calculated, as was the average weight of insects per sample on each transect.

During 1970, food habit samples collected from juvenile blue grouse revealed that grasshoppers were an important part of the diet. To determine grasshopper numbers, a grasshopper sampling method developed by the U. S. Department of Agriculture (U.S.D.A. 1969) was used. The observer first learned to visualize one square foot of ground by practicing with a measured square. When this was mastered, the technique consisted of visualizing a square foot a few yards ahead in the area to be sampled, walking toward the imaginary square, and counting the number of grasshoppers which jumped into or out of the square. Grasshopper counts also were made along the six vegetational transect lines. Thirty-six evenly spaced square-foot plots were sampled along each of the transects. A total count for each transect was obtained and a grasshopper/square yard average calculated. Counts were made on August 11 and 17 in 1971, August 10 and 17 in 1972, August 10 and 17 in 1973, and August 15 and 22 in 1974. Counts were confined to August because the grasshoppers were larger and easier to see at that time and because the juvenile grouse utilized them extensively for food during August.

Mound building ants were common on the study area. Food habit investigations since 1970 showed that young blue grouse eat ants. Therefore, it was decided to test the effects of herbicidal spraying on ant mounds. On June 8, 1971, numbered wooden stakes were driven into the ground next to 50 active ant mounds. Ten were on the control portion of the study area and 40 on the spray portion. It was hoped that periodic checks of mound activity would reveal any detrimental effects resulting from vegetational changes. Because the same mound usually is used by ant colonies for several years, (Dr. Donald Davis, Utah State University entomologist, personal communication), it was felt the marked mounds normally would become inactive at a slow, steady rate. Thus, any sudden drop in activity following herbicide spraying could be attributed to the effects of the spray. The mounds were checked for activity during the spring and fall of each year. Obviously, this procedure would not reveal any beneficial effects of spraying on mound ants.

RESULTS

Breeding. The breeding period began soon after the blue grouse migrated onto the study area in the spring. Depending upon snow melt conditions, this usually occurred in April. Males established their territories soon after arriving upon the study area, and breeding activity continued into June. Around mid-June, male territoriality decreased and males began to leave the area by late June. Because the peak of hatching was the third week of June during most of the study, and incubation lasts about 3 weeks, it was evident that most females were bred before June 1. Breeding behavior exhibited by males in June was, therefore, largely "ceremonial" in nature.

Female breeding behavior was not observed, but male breeding behavior often was. Two types of male vocalizations were heard. The first and more common type was a single vocal "hoot," which usually was given during the period just before sunrise and around sunset, although it occasionally was heard during the middle of the day. On calm mornings, "hoots" could be heard at a distance of 100 yards or more. The second vocalization, heard only in response to the playing of a recorded female call, consisted of a very soft buzzing sound. This was emitted for a second or two, stopped, then again repeated. This call was inaudible at distances exceeding 15 yards. A little wind often would make this call inaudible.

The male breeding display is quite colorful. The air sacs are puffed out, displaying the white feathers which surround them. The combs above the eyes become bright orange-red and the tail is fanned out, while a strutting type of dance is performed. The visual display frequently was performed without vocalizations. Males displaying on their territories sometimes would walk into the open for some distance. In response to recorded female calls, males would walk toward the recorder in full breeding display, coming within 10 yards of the observer on one occasion.

Because no territorial males were captured and marked, it was difficult to determine territory size accurately. Based on repeat sightings in a general area, however, mean territory sizes were estimated to be 1-2 acres, and probably closer to 1 acre. The topography of territories varied from almost level to fairly steep slopes, indicating that topography probably was not important in territorial selection. The aspect of some sloping territories may have been a factor in their selection. During the study, there was a relationship between snow melt patterns and the location of some territories. In several cases, males appeared to choose spots from which the snow first melted in the spring. Figure 8 shows the locations of all territories and possible territories located during the five-year study. The territories were numbered for reference only. Territories located on early snow melt sites were 4, 6, 8, 13, 15, and 16. All males which arrived in the spring first seemed to congregate on the early snow-free areas, later dispersing to the other territory sites as the snow melted from them. One male (territory 16) was observed hooting and displaying on a territory half covered with snow.

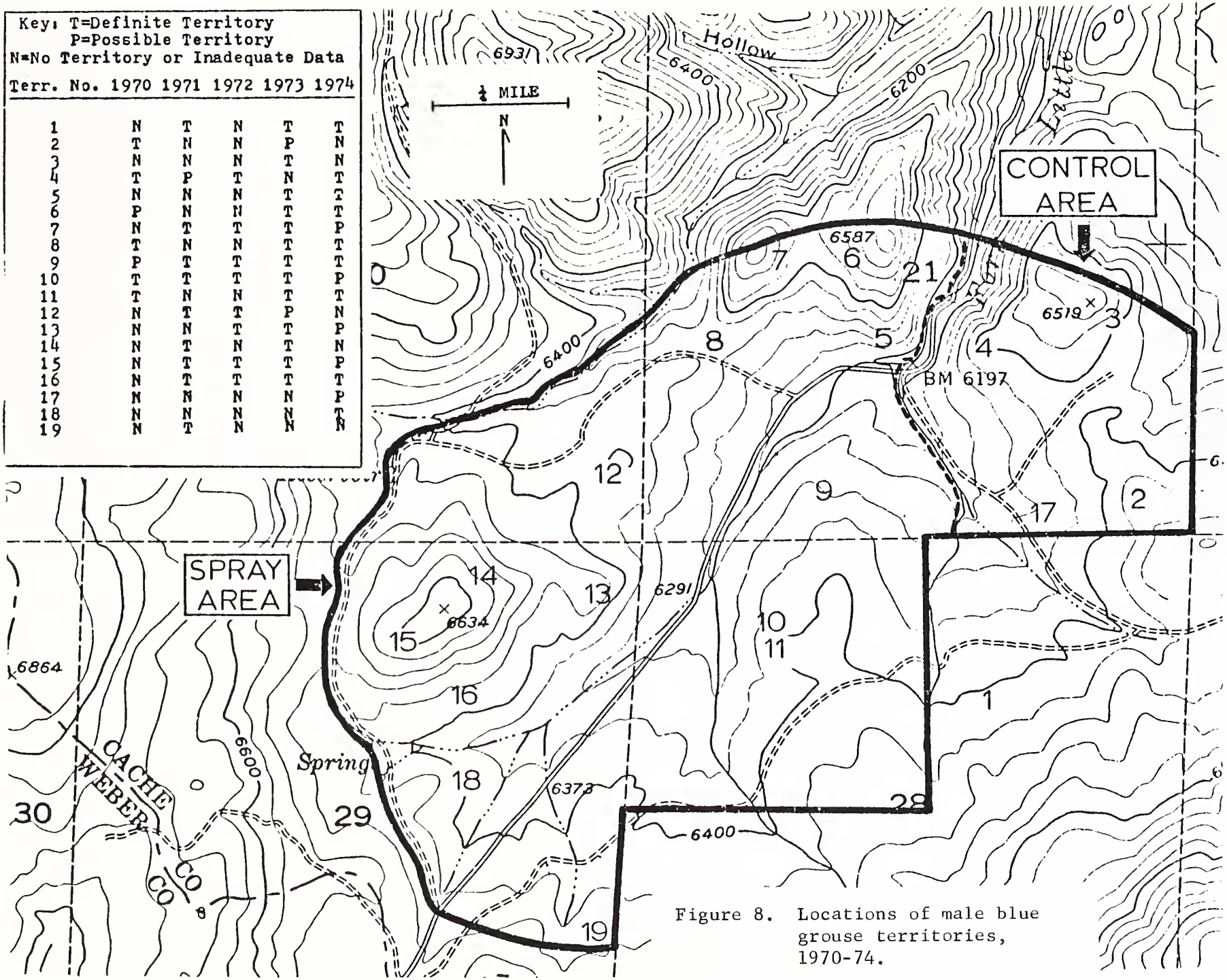

Figure 8. Locations of male blue grouse territories, 1970-74.

There was no evident connection between territory location and sources of free water. Breeding grouse probably obtained the moisture they required from consumed vegetation.

Vegetative cover obviously was the most important factor insofar as male blue grouse selecting a territory. Of the 19 territories shown in Figure 8, all but 4 were located either in open shrub and tree cover, or more typically on the border between tree cover and the open mule ears-sagebrush flats. The 4 exceptions (2, 3, 10, and 11) were located in thick stands of big sagebrush, which were 2-3 feet high and provided excellent cover. Big sagebrush was an important component of many territories, since it typically occurred in the transitional zones between wooded areas and open flats. Figures 9 and 10 show examples of typical territory sites on edges between open mule ears-black sagebrush flats (foreground, both photos) and semi-open wooded areas. Note the big sagebrush border between the open flats and the wooded hillside in Figure 10. Territory number 13 was located to the right of the junipers, extending out of the photo in Figure 10. Figure 11 shows 3 territory locations. Figure 12, which shows territory number 2, is typical of the big sagebrush type used for territories 2, 3, 10, and 11.

Two basic requirements for territories were: 1) escape cover, provided by trees and thick sagebrush; and 2) openness, presumably necessary so that the displaying male could be seen more readily by females.

Figure 8 shows the location of 19 territory or possible territory sites. Territory number 1 was located just to the east of the study area. Not all of the 19 sites were occupied by males each year, as shown by the table in the corner of Figure 8. Here is a year by year breakdown:

1970 - 5 territories, 2 possible territories
1971 - 8 territories, 1 possible territory
1972 - 8 territories
1973 -12 territories, 2 possible territories
1974 - 8 territories, 5 possible territories
(Note: territory number 1 was not included in these figures.)

It is felt that differences in the number of territories occupied/year was more a function of the observer's ability to find the territories than a true fluctuation in territory numbers. The 1973 figures probably best represent year-to-year territory numbers, because by then the methods of territory location had been developed to a high degree. More of the 1974 "possibles" would have been rated as definite, if I had been able to spend more than 2 weeks on the area in 1974. Some of the 19 territory sites probably were marginal in quality and occupied only in some years, perhaps by yearling males. I feel that territory numbers 3, 17, 19, and possibly 18 fall in this category.

Of the 19 definite and possible territory locations, 2 were completely sprayed with herbicide, 10 bordered on the sprayed area, and 7 were not

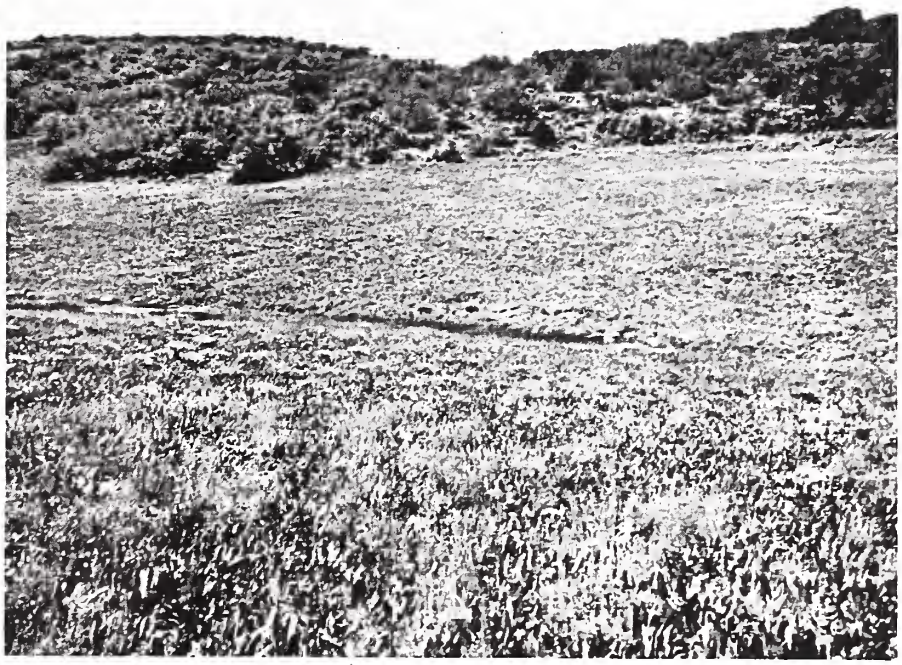

Figure 9. Typical site for a male blue grouse territory. Most territories border on open flats, but include woody cover. (Photo by D. A. Weber)

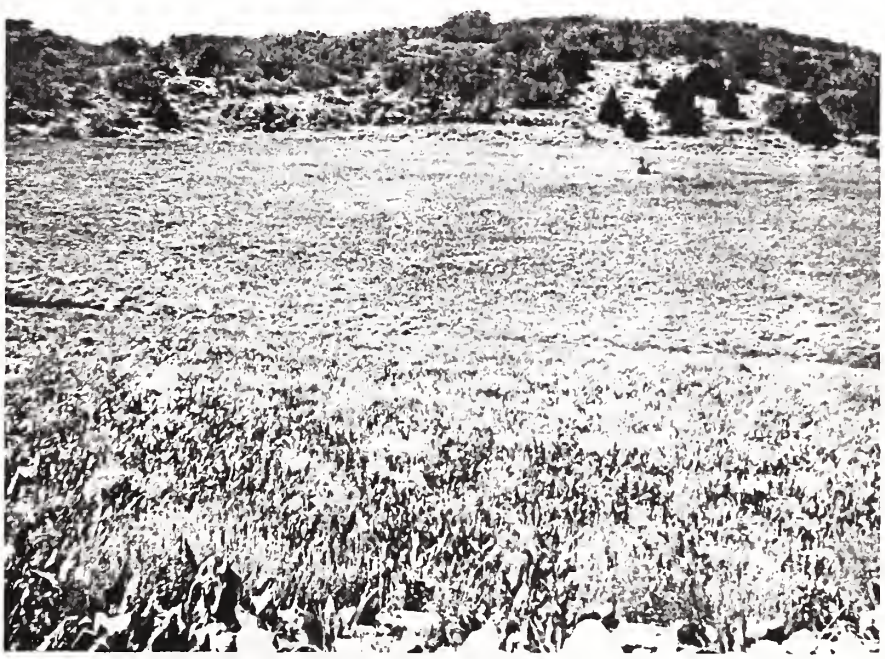

Figure 10. Male blue grouse territory site (right of photo along edge of trees). The dark junipers were a favorite resting spot for grouse. (Photo by (D. A. Weber)

Figure 11. A hill on the west side of the study area. Three territories are shown: #18 in trees (foreground), #15 at top of hill (left side of photo), and #16 in the trees at far right of hill in background. (Photo by D. A. Weber)

Figure 12. Typical big sagebrush type used for territories #2, 3, 10, and 11. Territory #2 shown here. (Photo by D. A. Weber)

near a sprayed area. Because the spraying generally was not done within 100 feet of any tree cover, it is doubtful that any of the 10 borderline territories were sprayed even partially. We saw no evidence that any of those 10 or 7 territory locations (Nos. 1, 2, 3, 4, 14, 15, and 17) were affected by the sprayings. The 1973 and 1974 post-spraying breeding seasons seemed to be similar to the previous 3 years, except for late snow melts in both years, which delayed the start of breeding.

The 2 territories which were completely sprayed (numbers 10 and 11) were located in a big sagebrush patch. Almost all the sagebrush was killed by the 1972 spraying, and the amount of cover provided by the dead sagebrush branches was poor, compared to pre-spraying conditions. The dead branches, which remained upright, were noticeably fewer in 1974 than in 1973. Dead branches probably were broken off by the weight of snow cover. The amount of cover in this sage patch probably will continue to decrease. Both territorial males were still using the sage patch in 1973, but the level of activity in 1974, as measured by grouse sightings, droppings located, and dusting bowls observed, dropped markedly. At least one male maintained his territory in the patch, but a second territory location was not confirmed. As the cover provided by dead sagebrush branches continues to decrease, I believe that male blue grouse no longer will use this area for territories. In 1970-72, the sage patch containing territories 10 and 11 probably was the most active breeding and roosting area for blue grouse on the study area.

In order to determine the food habits of breeding male and female blue grouse in the spring, fresh droppings were collected in 1971, 1973, and 1974 and examined in the laboratory under a binocular microscope to determine what the breeding blue grouse were eating. The bulk of the droppings (about 98% by volume) consisted of flowers, leaves, buds, and grass. Approximately 2% of the adult spring diet was insects (ants, beetles, spiders, and Lepidoptera larvae), but insects were almost insignificant in relation to the amount of plant material ingested. The only plant species recognized in the droppings was sagebrush buttercup, the flowers of which had been eaten by a territorial male blue grouse in April. This plant sprouts and blooms immediately after snow melt and was gone before the herbicidal sprayings occurred.

Nesting. As shown in Table 2, hatching on the study area peaked about the third week of June during most of the study, although the 1972 and 1974 data are sketchy and may indicate earlier peaks for those years. Allowing 3 weeks for incubation and 1 week for egg laying, nest site selection and construction must have taken place in mid-May during most years of the study. It is interesting to note that in 1973, when a late snow melt delayed the start of the breeding season, the peak of hatch occurred during the same period as in previous years with earlier snowmelt.

Sixteen blue grouse nests were located during the study (Figure 13). These were numbered for reference only. Five of the nests were found while still active, and 11 after they had hatched or been deserted. All of the nests were shallow (1-2 inches) ground depressions, about 6 inches in diameter. Most were lined with a few twigs and some had feathers as

Table 2. Hatching dates for blue grouse nests as determined by nest observations and back-dating from young grouse shot or caught alive.

TIME INTERVAL	Number of Nests Hatching During Period					
	1970	1971	1972	1973	1974	All Years
May 24-31	0	1	1	0	0	2
June 1-7	0	1	4	0	2	7
June 8-14	2	5	3	7	0	17
June 15-22	7	13	4	12	0	36
June 23-30	3	6	1	5	0	15
July 1-7	1	2	0	0	0	3
Total	13	28	13	24	2	80

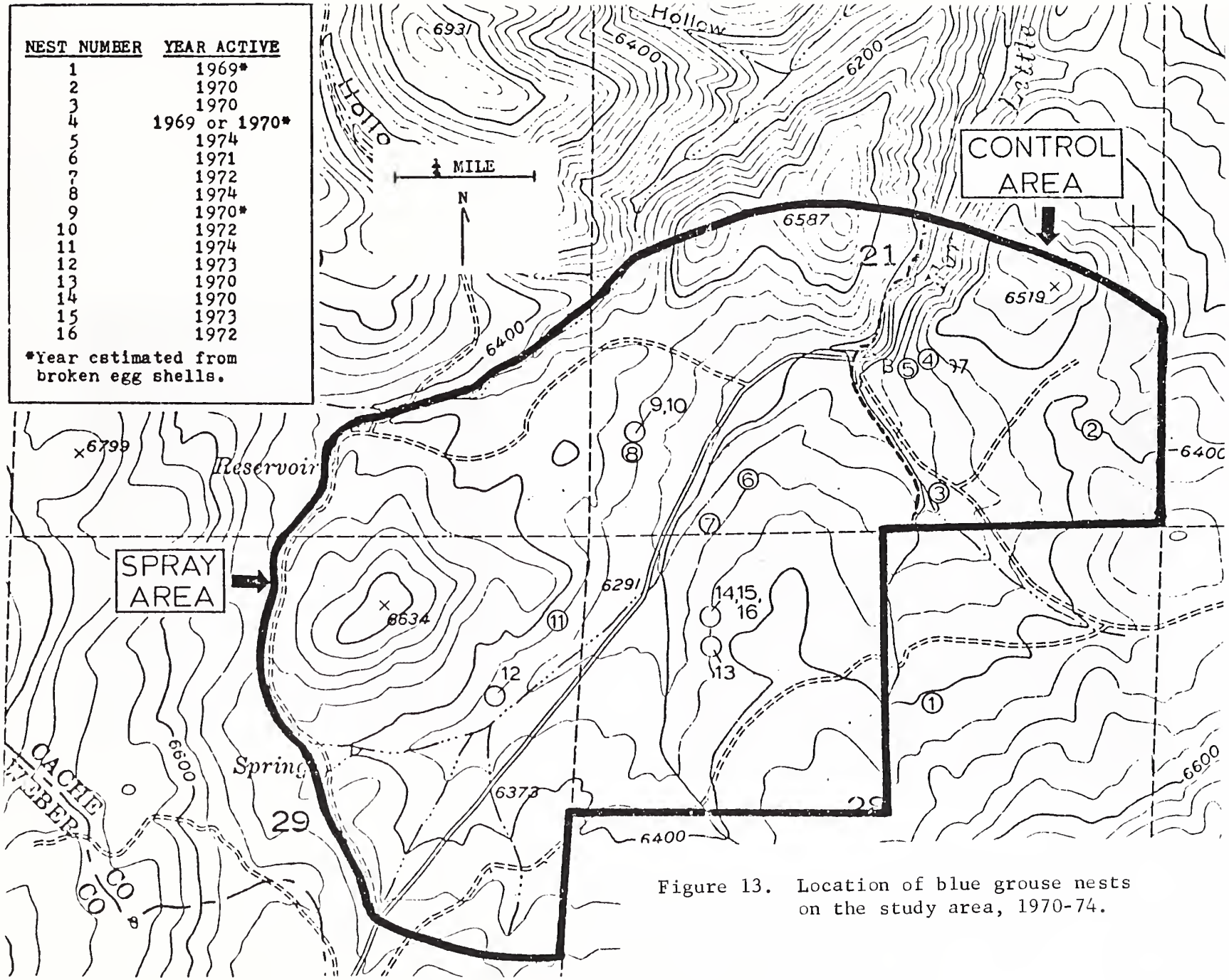

Figure 13. Location of blue grouse nests on the study area, 1970-74.

Figure 14. Blue grouse nest number 13 (see Figure 13). Note egg in foreground beginning to hatch. Three of the 6 eggs hatched, the remaining 3 were infertile. (Photo by D. A. Weber)

Figure 15. Blue grouse nest number 2. Seven of the 8 eggs hatched. The unhatched egg was fertile, but embryo development stopped at an early stage. (Photo by D. A. Weber)

additional lining material. Figures 14 and 15 show typical nests. Clutch sizes for seven complete nests (5 active, 1 deserted, and 1 located just after hatching) were 6, 7, 7, 7, 8, 9, and 9. The average clutch size was 7.6 eggs. One of the active nests was deserted before it hatched, but for the other 4 nests, only 17 of the 30 (57%) eggs hatched. This seems low, but is based on a small sample.

Females on nests held very tightly before flushing, expecially as the time of hatching neared. In one case, a horse stepped on a nesting female. I also stepped within a foot of a nesting female before she flushed. All females disturbed from nests returned to continue incubation, indicating that nest desertion probably is rare. Nesting hens deposited large "clocker" droppings, although not necessarily in the immediate vicinity of the nest. Examination of these droppings indicated that the diet of nesting females consisted almost entirely of plant material.

Of the 16 nests located, 14 were found under or immediately adjacent to sagebrush bushes. One was between a sagebrush bush and a clump of bunchgrass, and one was beneath a snowbush (Ceanothus velutinus) which was located in a big sagebrush patch. It was interesting that only one of the nests were located in a low, black sagebrush (nest #3), which was much more abundant than big sagebrush. Figures 16 and 17 show typical nest locations. The man in Figure 12 also is pointing to a nest (#2).

Nests were located on both flat and sloping sites, with a variety of aspects. Most nests were located within .25 miles of free water, but, because water was so widespread on the study area, it cannot be said that the nest locations were chosen because of the proximity of water. Almost all nests were located near male territories, some being on territories. I feel females probably nest close to the territory of the male which bred them.

Only 5 of the 16 nests were on areas which were herbicidally sprayed, and only 1 of the 5 was constructed after the spraying. This nest was found on May 28, 1973, (nest #15, Figure 13), and was under a big sagebrush plant which had been killed and defoliated by the 1972 herbicidal spraying. Cover for this nest was poorer than it would have been if the foliage had remained on the plant. The nest had been destroyed by a predator, either a skunk or a weasel, judging from toothmarks on the eggshells. It is difficult to say whether or not the lack of cover from the dead sage contributed to predation, although it is a possibility. The sagebrush under which nest site numbers 6, 13, 14, and 16 were hidden were defoliated by spraying. They then were dramatically visible.

Most nest sites were not sprayed, because they were located on the control slope or close to woody cover, which were not sprayed.

The almost universal use of big sagebrush for nesting cover by blue grouse was surprising. We expected to find nests under woody cover, but did not expect big sagebrush to be used so extensively. This is not to say that grouse do not nest in other vegetational types, but we did not find such. No literature references were found concerning blue grouse nesting in sagebrush, but personal communications from U. S. Forest

Figure 16. Typical blue grouse nest location, under big sagebrush plant. Note eggs in center of the photo. (Photo by D. A. Weber)

Figure 17. Blue grouse nest concealed under a big sagebrush plant. This is nest #12, discovered in June of 1973, just after the young had hatched. (Photo by D. A. Weber)

Service personnel have indicated that blue grouse nests have been found under sagebrush in Idaho and elsewhere in Utah. Frank Gunnell, U.S.F.S. wildlife biologist, located a nest just north of Porcupine Reservoir, Cache County, Utah, which was under a big sagebrush plant and similar to the nests found on the study area.

Brood-rearing. Blue grouse chicks left the nest within a few hours after hatching and remained as a group with the hen during most of the summer. One to 2-week-old chicks remained close to the hen most of the time and hens were protective of the chicks during that period. When the chicks reached 3 to 4 weeks of age, they wandered further from the hen to feed. When a brood was flushed, 1- to 2-week-old chicks usually froze in position, although they were capable of weak flight at about a week of age. Chicks older than 3 weeks usually flew with the hen when flushed. The hen from a flushed brood often flew to a nearby tree and began to call to the chicks, presumably to direct them to remain still and quiet until danger had passed. This call closely resembled the clucking of a hen chicken. The chicks usually would begin to give a "lost" call within 10 minutes after the hen was flushed. This call is a high pitched "peeeeeep," which apparently aids the hen in reassembling her brood. If the observer hid himself, the hen would return within 10 to 20 minutes to the area of flushing to locate the chicks. Some hens were more aggressive than others in protecting their chicks. On one occasion, after we had captured two chicks, the hen walked from cover, obviously extremely agitated, and moved directly toward us, coming within 5 feet before we captured her with a noosing pole.

By making re-sightings of color-marked juvenile grouse we determined the movement patterns of broods on the study area. The furthest recorded movement by a brood during the summer was only about 600 yards, indicating a limited range for broods during the summer.

Analyses of juvenile crop contents collected on the study area are presented in Table 3. Results from 68 juvenile crops collected over a 5-year period are summarized by months in which the grouse were collected. Only 5 crops were collected in June. Their contents were 67.5% and 32.5% insect and plant food, respectively. Lepidoptera larvae was the largest single food category, followed closely by seeds and grasshoppers. The 31 crops collected in July contained 88.1% insect material. By far the most important item in the July diet was grasshoppers, which comprised 81.6% of all crop contents. Some crops were so full of grasshoppers that they appeared ready to burst. The remainder of the July crop contents was well distributed among several categories: seeds of Polygonum douglasii (1.7%), Lepidoptera larvae (1.6%), rose hips (5.0%), and unidentified seeds (1.5%). Ants frequently were eaten, being found in 61.3% of the crops. However, they comprised only 1.3% of the total food volume.

The 26 crops collected in August samples contained: 61.3% insects and 38.7% plant material. Again, grasshoppers were the favored food, making up 60.1% of the volume. Amounts of other insect groups were not significant, although ants were found in 38.5% of the crops. Rose hips

Table 3. Results of the analyses of the contents of 68 juvenile blue grouse crops collected on the study area during the summer and fall, 1970-74.

Food Category	June (n=5)		July (n=31)		August (n=26)		September (n=6)	
	% by[a] Vol.	%[b] Occur.	% by Vol.	% Occur.	% by Vol.	% Occur.	% by Vol.	% Occur.
ANIMAL FOOD								
ORTHOPTERA								
Grasshoppers	15.7	20.0	81.6	64.5	60.1	88.5	26.7	33.3
Gryllidae (crickets)	--	--	--	--	--	--	0.5	16.7
HYMENOPTERA								
Formicidae (ants)	1.6	40.0	1.3	61.3	0.1	38.5	T	16.7
Other Hymenoptera	--	--	--	--	T	3.8	--	--
COLEOPTERA								
Carabidae	--	--	--	--	0.4	3.8	--	--
Curculionidae	--	--	0.1	12.9	--	--	--	--
Tenebrionidae	--	--	1.4	29.0	0.1	11.5	--	--
Coleoptera larvae	--	--	0.4	12.9	--	--	--	--
Other Ad. Coleoptera	7.9	40.0	T	6.4	T	7.7	T	16.7
HEMIPTERA								
Scutelleridae	--	--	--	--	0.1	7.7	--	--
Pentatomidae	--	--	T	3.2	--	--	7.4	16.7
Nabis spp. (damsel bugs)	--	--	0.1	16.1	T	3.8	--	--
Other Hemiptera	--	--	T	3.2	--	--	--	--
LEPIDOPTERA								
Lepidoptera larvae	39.2	60.0	1.6	25.8	0.1	3.8	--	--
Microlepidoptera	--	--	T	3.2	--	--	--	--
Moths	--	--	0.3	6.4	--	--	--	--

Table 3. cont.

Food Category	June (n=5) % by Vol.	June (n=5) % Occur.	July (n=31) % by Vol.	July (n=31) % Occur.	August (n=26) % by Vol.	August (n=26) % Occur.	September (n=6) % by Vol.	September (n=6) % Occur.
HOMOPTERA								
Cicadellidae	--	--	T	12.9	T	3.8	--	--
Membracidae	--	--	0.1	16.1	0.1	11.5	--	--
NEUROPTERA								
Raphidiidae	--	--	0.1	12.9	--	--	--	--
ARANEIDA								
Spiders	--	--	0.3	22.6	0.1	15.4	T	16.7
CHILOPODA								
Centipedes	--	--	--	--	T	3.8	0.1	16.7
DIPTERA	--	--	0.3	3.2	--	--	--	--
UNIDENTIFIED ANIMAL FOOD	3.1	40.0	0.4	32.2	0.2	19.2	--	--
PLANT FOOD								
Lactuca serriola (seed pods)	--	--	--	--	4.8	15.4	--	--
Lactuca serriola (leaves)	--	--	0.5	3.2	T	3.8	--	--
Rosa woodsii (rose hips)	--	--	5.0	3.2	18.6	30.8	--	--
Symphoricarpos oreophilus (berries)	--	--	--	--	1.2	3.8	2.7	16.7
S. oreophilus (leaves)	--	--	--	--	0.1	3.8	--	--
Amelanchier alnifolia (berries)	--	--	--	--	1.2	3.8	57.2	50.0
A. alnifolia (leaves)	--	--	--	--	0.1	3.8	0.1	16.7

Table 3. cont.

Food Category	June (n=5) % by Vol.	June (n=5) % Occur.	July (n=31) % by Vol.	July (n=31) % Occur.	August (n=26) % by Vol.	August (n=26) % Occur.	September (n=6) % by Vol.	September (n=6) % Occur.
Prunus virginiana(berries)	--	--	--	--	1.0	3.8	--	--
Tragopogon spp. (flower heads)	--	--	--	--	0.8	3.8	--	--
Quercus gambelii (acorns)	--	--	--	--	0.6	3.8	--	--
Cercocarpus ledifolis(leaves)	--	--	--	--	0.3	7.7	5.3	33.3
Salix spp. (leaves)	--	--	--	--	0.3	3.8	--	--
Agoseris glauca (seed heads)	--	--	--	--	--	--	1.1	16.7
Polygonum douglasii (seeds)	--	--	1.7	29.0	6.3	46.2	--	--
Purshia tridentata (leaves)	--	--	0.1	3.2	--	--	--	--
Artemisia spp. (leaves)	--	--	0.1	6.4	--	--	--	--
Unidentified Seeds	32.5	80.0	1.5	19.4	0.7	19.2	--	--
Unidentified Leaves	--	--	0.9	35.5	0.8	42.3	2.7	33.3
Unidentified Grass Leaves	--	--	0.1	3.2	0.1	15.4	0.6	33.3
Unidentified Plant Material	--	--	2.2	35.5	1.9	57.7	2.1	66.7
SUMMARY								
TOTAL ANIMAL FOOD	67.5	80.0	88.1	93.5	62.3	92.3	28.1	50.0
TOTAL PLANT FOOD	32.5	80.0	11.9	80.6	38.7	96.2	71.9	100.0

[a]% by Vol. refers to the percent of the total food volume (plant and animal) which the category comprises.
[b]% Occur. refers to the percent of the samples in which the food item occurred.

made up 18.6% of the August volume, seeds of Polygonum douglasii 6.3%, seed pods of prickly lettuce (Lactuca serriola) 4.8%, and snowberries and serviceberries each comprised 1.2% of the total volume. Six crops were collected in September. Only 28.1% of the contents of these were insects and 71.9% plant material. Again, grasshoppers made up the bulk of the insect food (26.7%). The most common plant materials consumed were serviceberry (57.2%), curlleaf mahogany leaves (5.3%), and snowberry (2.7%).

Based on results of crop analyses, juvenile blue grouse on the study area depended primarily on insects for the first portion of the summer, but shifted more toward plant materials as fall approached. The dependence of grouse upon grasshoppers was dramatic. Crops of juvenile grouse collected after herbicidal spraying contained a high percentage of grasshoppers, as had been the case prior to the herbicide application. Only two crops were collected in 1974, and both contained a high percentage of grasshoppers. I feel it unlikely that the herbicide treatment had much effect on the food habits of young grouse through 1974.

Table 4 shows average body weights for juvenile blue grouse in different age classes. Although sample sizes were small, it is evident that growth was fast, especially between 5 and 7 weeks of age.

Table 5 shows average blue grouse brood sizes by month on the study area for the 1970-74 study period. July brood size was about 5 chicks/brood in 1970, 1971, and 1973, but dropped to 4 chicks/brood in 1974. There may have been an actual drop in brood size in 1974, but the less experienced observer in 1974 also may not have been as successful in locating all the chicks in broods. An August brood size of 2.82 in 1974 was comparable with August counts for 1971 and 1972.

The estimated number of blue grouse broods on the study area during the last 4 years of the study were:

1971 - 18-20 broods
1972 - 17-20 broods
1973 - 19-22 broods
1974 - 17 broods

Insufficient information was gathered in 1970 to make an estimate, but brood numbers then appeared to be comparable to the above figures. Since nearly all the blue grouse nests located were under or next to sagebrush bushes, it was anticipated that the herbicidal sprayings and resulting defoliation of the sagebrush might ruin nesting cover and, thereby, decrease production. However, there were more broods on the study area in 1973 than in previous years, and in 1974 the number was comparable to pre-spraying levels. We can, therefore, demonstrate no effect of the vegetation change to date on the number of broods which use the study area in the summer.

Broods were found most often in mule ears-sagebrush vegetation along the edges of tree or tall shrub cover. The furthest a brood was found

Table 4. Results of body weight determinations of juvenile blue grouse collected in 1970, 1972, and 1973.

Age (Wks.)	No. in Sample	Range (Grams)	Mean (Grams)*
2	4	54-82	66
3	7	98-130	116
4	3	115-278	182
5	10	255-509	351
6	9	400-649	506
7	3	474-700	574
8	2	625-837	731
9	2	712-781	747

*All weights included the weight of crop contents.

Table 5. Average monthly blue grouse brood sizes on the Public Grove study area, 1970-74.

Month	1970 $\bar{X}$	1970 n	1971 $\bar{X}$	1971 n	1972 $\bar{X}$	1972 n	1973 $\bar{X}$	1973 n	1974 $\bar{X}$	1974 n	Total $\bar{X}$	Total n
June	--	--	8.00	1	--	--	6.00	2	--	--	6.67	3
July	5.11	9	4.78	32	--*	--*	5.06	16	4.00	25	4.63	82
August	4.37	16	3.12	26	3.14	14	2.00	1	2.82	9	3.36	66

*Counts were made during July of 1972, but the data were misplaced. If they are located, this information will become available in the future.

from woody cover in 1973 was 50 yards, most being within 10 yards of the trees. Results in 1974 and in previous years were similar. Obviously, broods spent most of their time in and around tree cover, probably for protection from predators, but also possibly because of shade. On a few rare occasions, broods were found far out into the open mule ears and black sagebrush, but these broods may have been moving from one group of trees to another. The mule ears provided good brooding cover for the grouse. The association of blue grouse broods with mule ears and the similar plant, arrowleaf balsamroot (Balsamorhiza sagittata), has been reported by several authors. Whether or not the broods sought out the mule ears for cover was not determined, because the plant was so widespread on the study area that it would have been difficult for broods not to be in mule ears or close to it. Because the herbicidal spraying was not done within 100 feet of tree cover, a band of mule ears and sagebrush was left untreated around the woody cover frequented by broods. I think that this band provided adequate cover and feeding areas for the broods and areas treated with the herbicide generally were used little by the broods even prior to the spraying. One aspen and maple grove (in the left background of Figure 3), was the center of brood activity on the study area. It was not uncommon to find 3 or more broods in the grove. The aspen understory was grassy and broods often were found in the tall grass under trees, as well as in the mule ears along the edge of the trees.

A question exists as to whether the broods were attracted to or needed free water. Until 1974, no particular relationship between the location of broods and free water was noted. Some authors have reported in other states broods were frequently found along streams, expecially in the morning and evening. Vann Covington observed that broods in 1974 seemed to be more dependent upon water sources, perhaps because the summer was dryer than usual. Water is well distributed on the study area and at least 5 seeps or streams stay moist throughout the summer. Broods may have made special trips to these water sources, but little such activity was noted until 1974. Wet areas may attract broods for reasons other than the availability of water. Insect numbers probably are higher around water and the cover often is better there. Temperatures near water sources generally are lower. This might have been an attractant to broods on hot summer days.

During late July and August, the broods tended to bunch together and it was not uncommon to flush 2 or more broods from a location. By mid-August, we began to find chicks away from hens, broods with different age chicks, and occasionally hens with no chicks. We assumed this meant that broods were breaking up and mixing together. Broods began to leave the study area by late August, and few blue grouse were on the study area by the late September hunting season.

Migration. Timing of the spring migration onto the study area seemed to be correlated with the melting of snow. The first blue grouse arrived just as the first bare patches in the snow cover appeared. In 1970, field work did not begin until mid-May and the grouse then were well established on the area. In 1971, the first grouse arrived

on the study area during the first week of April. In 1972, some grouse may have arrived during the end of March, and they definitely were present by the first of April. The 1973 season, as was mentioned, was one of a delayed snow melt. The first grouse were observed on the study area on April 19. In 1974, there again was a late snow melt. No observations were made, but it is likely that the timing of downward migration was similar to that in 1973.

Males seemed to be the first to appear in the spring, indicating they move onto the area about a week before the females. Males also were the first to leave in the fall. Most males disappeared from the study area by mid-July. On at least 3 occasions in late June or early July, 2 or more males were flushed from the same spot. On June 26, 1973, 5 males were flushed from a small sage patch on the control portion of the study area. Male blue grouse apparently group together just before migrating from the area. Since no adult male grouse were banded, we received no indication from band returns as to where the males were migrating. Thus, it is impossible to say where the males wintered; but James Peak, to the east of the study area, is a likely possibility. As mentioned previously, hens and chicks began to leave the study area in late August, and few remained by the end of September. Forty-five juvenile blue grouse were banded on the study area during the project. Table 1 is a listing of those captured and shows band numbers and tag colors. Six band returns were received from grouse hunters. Two were returned following each of the 1970, 1971, and 1972 hunting seasons. No bands were returned following the 1973 and 1974 seasons. Of the six band returns, 1 involved a grouse banded off the study area and is not important to this study. Four of the 5 other returns were from grouse shot on the slopes of James Peak, and 1 from a grouse shot about 1 mile southwest of the study area. A yearling male blue grouse, captured and banded on April 26, 1971, was sighted on the study area on September 25, 1971, just 50 yards from his initial capture site. For some reason, he had failed to migrate.

Vegetation. Tables 6 through 13 present a numerical description of the vegetation on the transects before and after herbicidal treatments. Tables 6 through 11 show the percent canopy coverage for the more common plant species on the spray and control portions of the study area during the 3 sampling periods: May, June, and July. Tables 12 and 13 show the percent occurrence of the more common plant species on the spray and control transects for the May, June, and July sampling periods.

It should be noted that there are several variables which may have influenced the results of the vegetation transects. Plant phenology changed somewhat from year to year, depending upon snow melt, air temperature, and precipitation. On May 1, 1973, some of the transects, which were completely bare on May 1 of 1971 and 1972, were covered with snow. The same situation existed in 1974. Vegetation readings purposely were delayed in 1973 and 1974 in order to sample the plants at the same stage of development as they had been in previous years. Another variable is the person reading the transects. Since the system for estimating canopy coverage is somewhat arbitrary, some variation may occur between observer's

Table 6. Average percent canopy cover of the more common plant species on the spray portion of the study area during May of 1971-74.

Plant Species	Percent Canopy Coverage			
	May 1-3 1971	May 1-3 1972	May 23-24 1973	May 22-24 1974
Litter	64.3(3.8)*	63.7(2.3)	53.2(4.4)	33.8(3.96)
Bare Ground	15.6(2.3)	15.9(3.8)	25.8(3.5)	36.7(3.69)
Rock	15.5(2.2)	17.2(2.5)	21.0(3.5)	11.6(2.28)
FORBS				
Achillea millefolium	1.4(0.6)	1.8(0.8)	2.0(0.8)	3.7(1.90)
Allium spp.	11.3(2.2)	9.0(1.8)	12.3(2.5)	14.9(3.50)
Claytonia lanceolata	4.2(1.3)	3.4(0.9)	4.2(1.2)	3.5(1.07)
Collinsia parviflora	1.9(0.6)	2.4(0.6)	1.2(0.5)	6.3(1.84)
Floerkea proserpin	4.3(1.5)	2.4(0.5)	5.4(2.1)	1.2(0.77)
Gayophytum diffusum	--	T	1.0(0.6)	--
Lithophragma glabra	1.6(0.6)	1.8(0.8)	1.1(0.6)	0.9(0.49)
Lupinus spp.	1.7(0.8)	0.5(0.3)	0.1(0.2)	0.1(0.19)
Madia glomerata	0.9(0.5)	--	0.3(0.3)	1.1(1.27)
Microseris nutans	1.9(0.7)	1.8(0.6)	1.4(0.6)	0.4(0.33)
Polygonum douglasii	--	--	--	1.4(1.15)
Ranunculus spp.	1.0(0.6)	0.8(0.4)	0.9(0.6)	0.7(0.42)
Senecio spp.	4.3(1.2)	3.7(1.1)	5.9(1.7)	3.0(1.02)
Viola purpurea	1.6(0.7)	1.1(0.5)	1.7(0.7)	1.8(0.91)
Wyethia amplexicaulis	9.7(1.7)	7.0(1.5)	15.1(3.1)	11.5(2.89)
GRASSES				
Agropyron spp.	2.4(1.2)	0.7(0.6)	3.1(1.2)	17.9(3.39)
Poa spp.	4.1(1.6)	3.2(1.5)	15.4(3.1)	20.6(4.17)
Stipa spp.	1.7(0.6)	1.5(0.6)	5.6(1.7)	3.7(1.67)
SHRUBS				
Artemisia nova	18.2(3.7)	21.7(4.2)	2.4(1.7)	1.5(1.29)

*The figure in parentheses is the 95% confidence interval for the mean.

Table 7. Average percent canopy cover of the more common plant species on the spray portion of the study area during June, 1971-74.

Plant Species	Percent Canopy Coverage			
	June 1-3 1971	June 1-3 1972	June 18-20 1973	June 12-14 1974
Litter	59.0(3.8)	64.4(3.7)	55.6(4.2)	44.5(4.39)
Bare Ground	17.8(2.3)	15.6(2.2)	26.0(4.8)	27.8(3.80)
Rock	17.3(2.6)	16.0(2.7)	19.8(3.3)	17.0(2.89)
FORBS				
Achillea millefolium	3.9(1.3)	2.3(0.8)	4.5(1.9)	6.3(1.98)
Allium spp.	7.8(1.6)	1.1(0.4)	7.3(1.7)	6.6(1.89)
Claytonia lanceolata	0.4(0.3)	--	--	--
Collinsia parviflora	4.3(1.3)	1.5(0.4)	0.5(0.4)	0.5(0.33)
Floerkea proserpina	6.3(2.2)	1.4(0.8)	2.1(1.6)	2.2(1.41)
Gayophytum diffusum	1.8(1.2)	1.9(0.9)	0.5(0.4)	0.4(0.51)
Lithophragma glabra	0.8(0.4)	T	--	T
Lupinus spp.	2.3(1.0)	2.1(0.9)	0.5(0.6)	0.2(0.26)
Madia glomerata	3.8(1.2)	--	0.6(0.4)	1.2(1.19)
Microseris nutans	3.5(1.2)	1.4(0.6)	1.7(0.8)	1.1(0.55)
Polygonum douglasii	2.2(0.8)	--	3.4(1.0)	8.8(2.80)
Ranunculus spp.	--	--	--	--
Senecio spp.	4.0(1.4)	3.6(1.2)	3.2(1.3)	4.8(1.54)
Viola purpurea	2.8(1.1)	1.5(0.7)	2.1(0.9)	2.5(1.46)
Wyethia amplexicaulis	44.2(4.8)	47.8(5.1)	37.7(5.3)	16.8(3.99)
GRASSES				
Agropyron spp.	2.3(1.0)	1.5(0.8)	5.4(2.2)	11.4(2.99)
Poa spp.	12.0(2.6)	13.4(3.2)	20.5(4.3)	24.6(4.80)
Stipa spp.	5.2(1.2)	7.0(2.0)	11.2(2.6)	15.8(3.75)
SHRUBS				
Artemisia nova	19.9(3.9)	19.5(4.1)	3.2(2.0)	2.7(1.91)

Table 8. Average percent canopy cover of the more common plant species on the spray portion of the study area during July of 1971-74.

Plant Species	Percent Canopy Coverage			
	June 1-3 1971	June 1-3 1972	June 18-20 1973	June 12-14 1974
Litter	51.7(3.6)	65.2(3.9)	53.3(4.0)	54.6(4.48)
Bare Ground	22.9(2.8)	16.4(2.5)	24.7(2.8)	31.4(3.80)
Rock	19.8(2.8)	15.6(2.7)	23.1(3.4)	21.7(2.19)
FORBS				
Achillea millefolium	4.9(1.8)	4.2(1.6)	4.2(1.4)	5.7(1.98)
Allium spp.	5.4(1.2)	0.7(0.4)	2.3(0.9)	2.7(1.49)
Claytonia lanceolata	--	--	--	--
Collinsia parviflora	--	0.6(0.3)	--	--
Floerkea proserpina.	--	--	--	--
Gayophytum diffusum	3.3(1.1)	1.5(0.3)	--	2.6(1.86)
Lithophragma glabra	--	--	--	--
Lupinus spp.	2.9(1.5)	1.6(1.4)	0.1(0.2)	0.5(0.56)
Madia glomerata	3.5(1.1)	T	0.4(0.5)	1.5(1.01)
Microseris nutans	--	T	--	--
Polygonum douglasii	2.4(0.6)	--	4.4(1.6)	6.9(2.27)
Ranunculus spp.	--	--	--	--
Senecio spp.	--	T	0.1(0.1)	T
Viola purpurea	1.2(0.6)	0.9(0.6)	0.4(0.3)	0.3(0.32)
Wyethia amplexicaulis	56.4(5.4)	58.3(2.7)	25.7(4.8)	20.4(4.56)
GRASSES				
Agropyron spp.	6.3(1.9)	5.0(2.0)	7.6(2.4)	28.5(5.47)
Poa spp.	7.8(2.5)	7.9(2.8)	12.1(3.2)	27.6(5.47)
Stipa spp.	10.0(2.2)	8.4(2.2)	13.2(3.2)	24.4(4.93)
SHRUBS				
Artemisia nova	24.8(4.6)	15.0(4.1)	3.2(2.2)	0.8(0.62)

Table 9. Average percent canopy cover of the more common plant species on the control portion of the study area during May of 1971-74.

Plant Species	Percent Canopy Coverage			
	May 1-3 1971	May 1-3 1972	May 23-24 1973	May 22-24 1974
Litter	62.9(5.4)	64.0(5.2)	50.8(6.6)	47.8(6.42)
Bare Ground	19.6(3.8)	17.5(2.9)	33.4(6.2)	23.1(4.23)
Rock	16.0(3.9)	15.6(4.0)	13.8(3.5)	13.4(4.07)
FORBS				
Achillea millefolium	3.6(1.8)	3.9(1.9)	4.8(2.4)	4.9(2.37)
Allium spp.	10.6(3.6)	6.4(2.6)	11.0(3.9)	9.8(3.63)
Claytonia lanceolata	5.4(1.7)	4.6(1.4)	5.6(2.0)	3.1(1.19)
Collinsia parviflora	3.0(1.2)	3.2(0.9)	7.1(2.7)	10.0(3.43)
Floerkea proserpina.	1.2(0.7)	0.5(0.5)	--	0.1(0.11)
Gayophytum diffusum	0.8(0.3)	0.4(0.4)	0.4(0.2)	--
Lithophragma glabra	0.4(0.4)	1.1(0.7)	0.6(0.5)	0.8(0.65)
Lupinus spp.	3.0(1.2)	2.1(1.3)	1.9(1.3)	3.2(1.81)
Madia glomerata	1.4(1.1)	--	0.5(0.2)	0.1(0.11)
Microseris nutans	1.2(0.9)	1.7(0.9)	3.1(1.7)	1.6(0.95)
Polygonum douglasii	--	--	--	0.3(0.39)
Ranunculus spp.	2.7(1.2)	1.1(0.6)	1.8(0.9)	0.3(0.38)
Senecio spp.	2.5(1.4)	3.1(1.6)	1.7(1.0)	2.9(1.43)
Viola purpurea	1.7(0.9)	1.0(0.7)	1.8(1.0)	1.0(0.81)
Wyethia amplexicaulis	22.6(4.4)	13.3(3.1)	34.6(6.4)	29.8(5.47)
GRASSES				
Agropyron spp.	2.8(1.7)	1.4(1.8)	6.0(2.4)	6.9(2.44)
Poa spp.	--	1.8(1.5)	3.7(1.8)	10.8(6.13)
Stipa spp.	2.2(2.2)	2.3(1.7)	4.6(2.8)	3.0(1.62)
SHRUBS				
Artemisia nova	26.1(5.7)	25.0(6.5)	20.0(6.6)	15.8(4.82)

Table 10. Average percent canopy cover of the more common plant species on the control portion of the study area during June of 1971-74.

Plant Species	Percent Canopy Coverage			
	June 1-3 1971	June 1-3 1972	June 18-20 1973	June 12-14 1974
Litter	55.4(4.0)	58.6(5.8)	66.7(5.6)	63.8(5.75)
Bare Ground	30.2(4.7)	22.4(4.1)	20.6(3.7)	14.6(4.07)
Rock	15.1(4.1)	15.9(3.6)	16.5(4.5)	16.2(8.34)
FORBS				
Achillea millefolium	9.2(3.8)	4.0(1.9)	11.7(4.3)	12.0(4.53)
Allium spp.	6.1(2.0)	0.2(0.2)	3.2(1.6)	2.9(1.47)
Claytonia lanceolata	--	--	--	--
Collinsia parviflora	1.4(0.7)	4.4(1.1)	0.7(0.5)	--
Floerkea proserpina.	1.2(1.2)	0.3(0.4)	--	--
Gayophytum diffusum	6.7(1.8)	2.0(0.9)	7.9(2.8)	9.1(2.70)
Lithophragma glabra	0.3(0.4)	--	--	--
Lupinus spp.	4.1(1.0)	3.8(2.1)	5.0(2.4)	7.0(3.16)
Madia glomerata	3.8(1.6)	T	2.3(1.0)	2.3(1.44)
Microseris nutans	2.1(1.0)	1.0(0.6)	2.8(1.4)	1.0(0.65)
Polygonum douglasii	3.5(1.1)	--	3.8(1.1)	2.0(1.45)
Ranunculus spp.	--	--	--	--
Senecio spp.	6.0(2.8)	0.8(0.6)	1.8(1.2)	2.3(1.15)
Viola purpurea	1.4(0.9)	0.9(0.6)	1.6(1.4)	2.6(1.77)
Wyethia amplexicaulis	45.2(7.3)	49.1(7.2)	51.5(7.6)	42.4(3.55)
GRASSES				
Agropyron spp.	3.7(2.2)	1.6(1.4)	7.8(3.6)	16.2(5.29)
Poa spp.	10.1(3.5)	9.8(2.9)	17.1(5.5)	19.5(7.13)
Stipa spp.	3.7(1.7)	4.8(2.4)	8.8(3.6)	13.6(5.35)
SHRUBS				
Artemisia nova	34.1(6.6)	27.2(6.1)	32.6(6.9)	27.5(6.48)

Table 11. Average percent canopy cover of the more common plant species on the control portion of the study area during July 1971-74.

Plant Species	Percent Canopy Coverage			
	July 1-3 1971	July 1-3 1972	July 21-23 1973	July 10-11 1974
Litter	55.7(5.8)	66.0(5.1)	59.3(5.7)	68.7(5.30)
Bare Ground	23.7(4.6)	14.7(3.2)	23.0(4.2)	19.3(4.19)
Rock	16.9(3.6)	14.9(3.4)	18.2(4.9)	13.2(3.66)
FORBS				
Achillea millefolium	7.6(2.8)	5.1(2.1)	9.3(3.3)	8.8(3.12)
Allium spp.	5.3(2.6)	0.6(0.4)	1.3(0.7)	1.3(0.88)
Claytonia lanceolata	--	--	--	--
Collinsia parviflora	--	6.0(2.0)	--	--
Floerkea proserpina.	--	T	--	--
Gayophytum diffusum	4.3(1.4)	1.4(0.3)	5.9(2.4)	8.3(1.68)
Lithophragma glabra	--	--	--	--
Lupinus spp.	8.5(3.9)	2.8(1.8)	3.8(1.9)	7.3(3.95)
Madia glomerata	6.2(2.3)	T	2.3(1.5)	5.5(3.39)
Microseris nutans	--	--	--	--
Polygonum douglasii	2.7(0.8)	--	3.8(1.0)	0.8(0.43)
Ranunculus spp.	--	--	--	--
Senecio spp.	--	T	--	--
Viola purpurea	1.2(1.1)	0.2(0.1)	--	--
Wyethia amplexicaulis	57.5(7.8)	49.1(7.4)	49.8(7.2)	37.9(6.63)
GRASSES				
Agropyron spp.	10.1(3.5)	5.7(2.7)	9.6(3.5)	12.5(5.05)
Poa spp.	5.9(3.3)	7.9(4.0)	9.0(4.1)	19.5(7.41)
Stipa spp.	5.4(2.8)	4.0(2.3)	6.8(2.8)	14.8(5.30)
SHRUBS				
Artemisia nova	31.7(7.1)	27.6(6.3)	30.9(6.4)	27.8(6.95)

Table 12. The percent occurrence of the more common plant species on the spray portion of the study area during 1971-74.

Plant Species	PERCENT OCCURRANCE											
	MAY				JUNE				JULY			
	1971	1972	1973	1974	1971	1972	1973	1974	1971	1972	1973	1974
Litter	100	100	100	100	100	100	100	100	100	99	99	100
Bare Ground	95	92	91	100	96	92	96	100	97	84	97	99
Rock	96	93	98	100	93	92	98	100	98	84	100	100
FORBS												
Achillea millefolium	30	30	26	29	31	35	24	31	34	33	33	31
Allium spp.	66	65	55	50	59	30	51	43	57	14	42	14
Claytonia lanceolata	39	44	34	39	10	--	--	--	--	--	--	--
Collinsia parviflora	56	62	23	61	52	51	8	9	--	18	--	--
Floerkea proserpina.	36	28	36	14	30	29	8	10	--	--	--	--
Gayophytum diffusum	--	1	17	--	22	38	6	6	49	56	--	11
Lithophragma glabra	28	26	14	16	15	1	--	1	--	--	--	--
Lupinus spp.	28	14	3	2	21	23	3	1	19	13	2	3
Madia glomerata	16	--	5	--	37	--	11	9	32	3	4	13
Microseris nutans	28	33	15	8	32	26	19	18	--	2	--	--
Polygonum douglasii	--	--	--	12	37	--	55	59	54	--	44	46
Ranunculus spp.	11	17	9	13	--	--	--	--	--	--	--	--
Senecio spp.	39	39	38	26	24	33	28	33	--	1	2	1
Viola purpurea	22	19	21	17	26	26	21	21	15	15	8	2
Wyethia amplexicaulis	75	73	63	49	89	86	76	49	91	83	66	53
GRASSES												
Agropyron spp.	17	6	19	69	17	16	19	39	39	31	42	58
Poa spp.	29	19	61	49	48	68	51	54	35	45	43	56
Stipa spp.	26	29	34	23	49	50	48	48	56	51	52	56
SHRUBS												
Artemisia nova	65	74	9	7	74	64	10	8	68	49	10	6

Table 13. The percent occurrence of the more common plant species on the control portion of the study area during 1971-74.

Plant Species	PERCENT OCCURRENCE											
	MAY				JUNE				JULY			
	1971	1972	1973	1974	1971	1972	1973	1974	1971	1972	1973	1974
Litter	100	100	100	100	100	100	100	100	100	100	100	100
Bare Ground	99	99	94	100	98	93	94	100	91	88	99	100
Rock	96	93	95	100	96	90	98	100	96	91	99	100
FORBS												
Achillea millefolium	30	35	36	38	38	38	48	49	46	39	50	40
Allium spp.	41	43	49	46	41	9	36	25	40	19	26	13
Claytonia lanceolata	48	63	51	43	--	--	--	--	--	--	--	--
Collinsia parviflora	64	79	78	84	44	88	14	69	--	86	--	--
Floerkea proserpina.	21	9	--	4	6	8	--	--	--	58	--	--
Gayophytum diffusum	34	9	15	--	76	61	85	60	68	58	66	60
Lithophragma glabra	10	19	12	13	6	--	--	--	--	--	--	--
Lupinus spp.	45	30	21	28	41	29	26	29	40	26	30	28
Madia glomerata	26	--	21	4	46	--	35	38	46	3	34	40
Microseris nutans	12	25	21	21	26	23	24	21	--	--	--	--
Polygonum douglasii	--	--	--	6	71	--	69	44	75	--	76	25
Ranunculus spp.	31	31	26	4	--	--	--	--	--	--	--	--
Senecio spp.	26	28	19	29	32	18	24	25	--	3	--	--
Viola purpurea	22	14	20	9	19	16	15	14	11	6	--	--
Wyethia amplexicaulis	81	71	80	85	84	86	89	79	84	84	90	76
GRASSES												
Agropyron spp.	15	8	35	60	21	10	28	49	56	33	42	41
Poa spp.	--	14	25	43	55	73	48	40	24	41	32	34
Stipa spp.	11	15	22	3	30	34	32	39	40	34	39	39
SHRUBS												
Artemisia nova	79	76	69	63	84	76	81	73	71	69	79	70

estimates. In 1971, Weber and Barnes each read half of the transects. Barnes read all of the transects in 1972. Weber read all of them in 1973. And, Vann Covington read them in 1974.

The most common plant species on the vegetation transects were mule ears and black sagebrush. These also were the 2 species with the most potential importance to blue grouse, mostly for cover and harboring insects important in juvenile grouse diets. The 1971 and 1972 plant readings were considered as pre-spraying readings (the first herbicide application was made in June of 1972 and did not affect the May or June transect readings). There may have been some effect on the July 1972 readings, particularly in the case of black sagebrush. The 1973 readings will be considered to measure the effects of the 1972 herbicide treatment, and the 1974 readings can be considered to measure the short-term cumulative effects of both the 1972 and 1973 herbicide applications.

The effects of the herbicide treatment on black sagebrush were dramatic. Prior to treatment, the mean canopy cover of black sage on the spray transects was 19.7% in June. In June of 1973, this had been reduced to only 3.2%, and in 1974 to 2.7%. Prior to the spraying, black sagebrush occurred on an average of 69% of the plots sampled on the spray transects in June. In 1973, it occurred on only 10% of the plots, and in 1974 on only 8% of the plots during June. June is the most representative sampling period for black sagebrush, but the results were similar in the May and July samplings. As the tables show, a similar drop in the amount of black sage on the control transects did not occur. The cumulative effect of the 2 herbicide treatments on black sage was that it reduced canopy coverage by 17% and percent occurrence by 61%.

The pre-spraying (1971-72 average) percent canopy coverage of mule ears on the spray transects during June was 46.0%. In 1973, following the first treatment, the percent canopy cover of mule ears in June dropped to 37.7% on the sprayed transects. In 1974, following the second treatment, the June canopy coverage dropped to 16.8%. June also was considered to be the most representative sampling month for mule ears, because during the May sampling period the mule ears are still growing and during the July period it is beginning to dry up. It is about at its peak of growth during June. Mule ears occurred on an average of 87.5% of the sampling plots during the June sampling before spraying. In 1973, occurrence dropped to 76%, and in 1974 it dropped to 49%. Similar drops in canopy cover or percent occurrence for mule ears did not occur during the June sampling period on the control area. The cumulative effect of the 2 herbicide treatments on mule ears was to reduce its canopy coverage by 29% and its percent occurrence by 38%.

It was anticipated that one of the effects of the herbicide treatment would be to increase the amount of grass when competing mule ears and sagebrush were reduced. The most representative sampling period for grasses is the July sampling, because grasses then are at their peak of growth and are mostly flowering, which aids in species identification. In comparing the pre-spraying and post-spraying figures

for the July sampling period for the 3 most common grass genera, Poa, Stipa, and Agropyron, a general increase in canopy cover percentages was evident. In July of 1973, following the first treatment, all 3 grass groups showed modest increases in percent canopy coverage, although percent occurrence did not increase correspondingly. This would be expected if there was not an increase in the number of grass plants, but the existing plants grew larger, producing a higher canopy cover percentage. On the control transects during July of 1973, however, there also was an increase in the percent canopy cover of all 3 grass groups. Since the increases were of about the same magnitude on both control and spray transects, it is unlikely that the 1972 spraying significantly increased the amount of grasses in 1973. The increase might have been due to the increased moisture available in the soil because of the late snow melt in 1973. In 1974, the percent canopy cover figures for July again increased on both the spray and control transects. In the case of Poa and Stipa, the percent increases were approximately equal on the spray and control transects, indicating no net effect caused by the herbicide treatment. Agropyron, however, increased to approximately 5 times the pre-spraying level on the sprayed transects, while only increasing slightly over pre-spraying levels on the control transects. Apparently the wheatgrasses (Agropyron sp.) responded favorably to the reduction of mule ears and black sage.

The only common forb species which appeared to have been reduced significantly by the herbicidal treatment were lupine and ground smoke, both of which showed marked drops in both canopy cover and percent occurrence on the spray transects. No corresponding reductions occurred on the control area. Some of the forbs bloomed and dried up before the herbicidal treatment was applied. Among these were spring beauty, sagebrush buttercup, groundsel, and woodland star (Lithophragma glabra). One would not expect these species to be killed by the spray and the data show they were not.

In summary, the herbicide treatments had the effect of significantly reducing mule ears, black sagebrush, lupine, and ground smoke, while causing a large increase in the amount of wheatgrass. It should be emphasized that these are short-term results and in time other species may increase or decrease as a result of the treatment.

Insects. Insect populations were sampled in 3 ways: small insect transects, grasshopper count transects, and ant mound activity monitoring.

Tables 14 through 17 document the average number of insects/sample occurring on the spray and control transects for the 4 years of the sampling. Table 18 shows the average total oven dry weight of insects/sample over the same period.

As for the number of insects/sample figures, there is a wide variability from year to year and even from one sampling period to another within years. This variability can be explained in many ways. One cause might be inherent differences in the number of insects to be sampled. In other words, the population might have been changing enough to cause differences in the insects collected. Another variable

Table 14. Average number of insects per sample on the spray transects during the first sampling period 1971-74.

CLASSIFICATION	June 29-30 1971	June 27 1972	July 4-6* 1973	July 6-7* 1974
HYMENOPTERA				
Formicidae (ants)	13.47(3.95)[a]	4.94	2.19(0.83)	4.16(1.65)
SF Chalcidoidea	.12(0.20)	.17	.03(0.06)	0.16(0.16)
Other Hymenoptera	.22(0.18)	.28	.22(0.20)	0.22(0.18)
HOMOPTERA				
Cicadellidae	5.03(1.56)	.88	.53(0.36)	4.47(4.37)
Membracidae	.03(0.06)	.72	.16(0.13)	0.16(0.16)
Ortheziidae	.16(0.26)	--	--	--
Other Homoptera	--	.56	.25(0.28)	0.06(0.13)
Cercopidae	--	--	--	0.13(0.12)
ORTHOPTERA				
Gryllidae	--	--	--	0.06(0.13)
1st Instar Grasshoppers	.12(0.12)	.25	.03(0.06)	0.41(0.29)
Other Grasshoppers	1.31(0.52)	.53	.91(0.39)	0.25(0.25)
HEMIPTERA				
Nabis spp.	.50(0.29)	--	.53(0.26)	1.13(0.47)
Miridae	--	.06	--	0.13(0.24)
Other Hemiptera	.50(0.35)	.19	--	0.28(0.21)
COLEOPTERA				
Curculionidae	.50(0.37)	.03	--	0.13(0.12)
Other Coleoptera	.62(0.36)	.53	.06(0.09)	0.25(0.24)
LEPIDOPTERA				
Lepidoptera larvae	--	--	--	--
Unidentified moths	.59(0.39)	.28	.16(0.21)	--
DIPTERA				
All Diptera	1.66(0.56)	.56	.34(0.20)	1.91(0.90)
THYSANURA				
Machilidae	.25(0.24)	.16	.47(0.35)	0.69(0.40)
ARANEIDA				
Spiders	.62(0.34)	.59	.31(0.25)	0.34(0.25)
TRICHOPTERA				
Caddisflies	--	--	--	--
NEUROPTERA				
Raphidiidae	--	--	--	--
UNIDENTIFIED INSECTS	.53(0.30)	.53	.12(0.12)	0.03(0.06)

[a]Figure in parentheses is the 95% confidence interval for the mean.

*The June sampling was purposely delayed 1 week because of a late snow melt in 1973 and 1974.

Table 15. Average number of insects per sample on the spray transects during the second sampling period 1971-74.

CLASSIFICATION	July 13-14 1971	July 13 1972	No Collection* 1973	July 20-21** 1974
HYMENOPTERA				
Formicidae (ants)	9.53(3.69)[a]	2.13		1.75(0.84)
SF Chalcidoidea	.16(0.13)	.94		0.06(0.09)
Other Hymenoptera	.62(0.13)	.94		0.22(0.22)
HOMOPTERA				
Cicadellidae	1.84(0.69)	.40		1.09(0.43)
Membracidae	1.00(0.91)	.19		0.56(0.55)
Ortheziidae	.97(1.37)	--		--
Cercopidae	--	--		0.09(0.19)
Other Homoptera	--	.19		0.06(0.13)
ORTHOPTERA				
Gryllidae	.34(0.70)	--		0.03(0.06)
1st Instar Grasshoppers	.81(0.62)	--		--
Other Grasshoppers	.75(0.32)	.06		0.03(0.06)
HEMIPTERA				
Nabis spp.	.59(0.32)	--		0.66(0.38)
Miridae	--	--		0.13(0.14)
Other Hemiptera	.53(0.37)	.03		0.28(0.16)
COLEOPTERA				
Curculionidae	.56(0.37)	.06		0.06(0.09)
Other Coleoptera	.44(0.29)	--		0.16(0.13)
LEPIDOPTERA				
Lepidoptera larvae	.03(0.06)	--		0.03(0.06)
Unidentified moths	.19(0.15)	--		0.06(0.09)
DIPTERA				
All Diptera	.38(0.24)	--		0.34(0.37)
THYSANURA				
Machilidae	.50(0.39)	--		0.50(0.29)
ARANEIDA				
Spiders	.62(0.35)	.25		0.38(0.30)
TRICHOPTERA				
Caddisflies	--	--		--
NEUROPTERA				
Raphidiidae	--	--		--
UNIDENTIFIED INSECTS	.47(0.27)	.19		0.03(0.06)

[a]Figure in parentheses is the 95% confidence interval for the mean.
*No collection was made in July of 1973 because of mechanical failure of the D-Vac machine
**The 2nd 1974 collection was delayed purposely because of a late snow melt.

Table 16. Average number of insects per sample on the control transects during the first sampling period, 1971-74.

CLASSIFICATION	June 29-30 1971	June 27 1972	July 4-6* 1973	July 6-7* 1974
HYMENOPTERA				
Formicidae (ants)	7.06(2.38)[a]	3.69	1.62(0.78)	5.50(1.77)
SF Chalcidoidea	.06(0.13)	--	.12(0.18)	0.13(0.18)
Other Hymenoptera	.12(0.18)	.12	.31(0.32)	0.38(0.33)
HOMOPTERA				
Cicadellidae	2.25(0.98)	2.19	3.44(1.29)	4.50(2.10)
Membracidae	--	--	1.44(1.06)	4.50(5.34)
Ortheziidae	.06(0.13)	--	--	--
Other Homoptera	.06(0.13)	1.19	1.38(1.06)	0.13(0.18)
Cercopidae	--	--	--	0.06(0.13)
ORTHOPTERA				
Gryllidae	--	--	--	--
1st Instar Grasshoppers	.25(0.36)	.06	.25(0.31)	0.19(0.21)
Other Grasshoppers	.88(0.47)	.44	.44(0.43)	--
HEMIPTERA				
Nabis spp.	1.31(0.77)	--	1.25(0.69)	0.63(0.43)
Miridae	--	--	--	0.38(0.80)
Other Hemiptera	.56(0.64)	.06	--	0.31(0.32)
COLEOPTERA				
Curculionidae	.12(0.18)	--	--	0.13(0.27)
Other Coleoptera	.69(0.82)	.19	--	0.13(0.18)
LEPIDOPTERA				
Lepidoptera larvae	--	--	--	0.06(0.13)
Unidentified moths	.38(0.26)	.19	.12(0.18)	0.13(0.18)
DIPTERA				
All Diptera	.94(0.71)	.19	.62(0.43)	1.13(0.58)
THYSANURA				
Machilidae	--	.12	.25(0.24)	0.44(0.47)
ARANEIDA				
Spiders	1.00(0.51)	.25	.69(0.46)	0.25(0.30)
TRICHOPTERA				
Caddisflies	--	--	.12(0.18)	--
NEUROPTERA				
Raphidiidae	--	--	.06(0.13)	--
UNIDENTIFIED INSECTS	.44(0.22)	.19	.31(0.32)	--

[a]Figure in parentheses is the 95% confidence interval for the mean.
*The June sampling was purposely delayed 1 week because of a late snow melt in 1973 and 1974.

Table 17. Average number of insects per sample on the control transects during the second sampling period 1971-74.

CLASSIFICATION	July 13-14 1971	July 13 1972	No Collection* 1973	July 20-21** 1974
HYMENOPTERA				
Formicidae (ants)	2.38(1.26)[a]	1.63		3.00(1.13)
SF Chalcidoidea	.12(0.18)	--		0.06(0.13)
Other Hymenoptera	.56(0.48)	.31		0.25(0.31)
HOMOPTERA				
Cicadellidae	2.19(0.89)	.25		6.69(3.30)
Membracidae	2.38(0.53)	.31		3.94(2.56)
Ortheziidae	--	--		--
Other Homoptera	--	.25		--
Cercopidae	--	--		0.06(0.13)
ORTHOPTERA				
Gryllidae	.81(0.51)	--		--
1st Instar Grasshoppers	.31(0.42)	.06		0.06(0.13)
Other Grasshoppers	.62(0.23)	.06		0.31(0.32)
HEMIPTERA				
Nabis spp.	.75(0.36)	--		1.06(0.77)
Miridae	.12(0.18)	--		--
Other Hemiptera	.25(0.31)	--		0.13(0.18)
COLEOPTERA				
Curculionidae	.38(0.33)	--		0.13(0.18)
Other Coleoptera	.19(0.21)	.12		0.25(0.31)
LEPIDOPTERA				
Lepidoptera larvae	.06(0.13)	--		--
Unidentified moths	.06(0.13)	--		0.38(0.26)
DIPTERA				
All Diptera	.12(0.18)	.06		0.44(0.43)
THYSANURA				
Machilidae	.62.(0.93)	--		0.50(0.48)
ARANEIDA				
Spiders	.75(0.36)	.06		0.44(0.48)
TRICHOPTERA				
Caddisflies	--	--		--
NEUROPTERA				
Raphidiidae	--	--		--
UNIDENTIFIED INSECTS	.62(0.39)	.12		0.25(0.48)

[a]Figure in parentheses is the 95% confidence interval for the mean
*No collection was made in July of 1973 because of mechanical failure of the D-Vac machine.
**The 2nd 1974 collection was delayed because of a late snow melt.

Table 18. Average oven dry weight of insects/sample for six transects on the study area during two sampling periods in 1971, 1972, and 1974 and one sampling period in 1973*.

Transect Number	Weight of Insects per Sample (mg)						
	June 29-30 1971	July 13-14 1971	June 27-28 1972	July 12 1972	July 4-6 1973	July 6-7 1974	July 20-21 1974
Spray Transects							
1	21.8(17.4)**	27.8(10.9)	25.7(6.9)	3.0(2.4)	9.8(3.6)	13.7(7.8)	5.6(2.8)
2	26.7(23.9)	30.5(25.5)	10.9(5.3)	6.6(4.3)	24.8(11.7)	25.0(23.8)	19.9(18.0)
5	29.9(13.4)	33.2(16.9)	9.0(5.7)	8.7(8.2)	19.1(19.8)	23.4(18.4)	20.1(18.5)
6	31.7(3.5)	23.4(5.8)	30.0(16.6)	6.9(4.7)	10.2(5.6)	52.2(36.1)	17.8(9.7)
Control Transects							
3	15.2(7.7)	15.5(7.5)	14.4(7.9)	11.8(9.5)	30.8(22.9)	17.6(9.7)	28.4(16.4)
4	17.8(5.7)	21.9(10.6)	10.7(4.4)	4.3(3.2)	9.8(5.7)	30.2(22.1)	38.9(15.9)

*Only one sampling was made in 1973 because of a mechanical breakdown of the D-Vac insect collecting machine. The 1973 and 1974 samplings were purposely delayed because of late snow melts in those years.
**The figure in parentheses is the 95 percent confidence interval for the mean.

was the D-Vac insect collecting machine may have been running more smoothly on one day than another and it, therefore, would collect more or fewer insects. A third possible factor is ground conditions at collecting times. Although collections were made only on sunny days which were fairly dry, moisture and/or wind conditions close to the ground could have affected the collections. In summation, the D-Vac vacuum method of insect sampling proved less than satisfactory. Discussions with Dr. Donald Davis, Utah State University entomologist, convinced me that a better method was not available. At any rate, if a long-term change in vegetation causes insect numbers or species composition to drastically change, comparison with the figures presented here will show roughly the nature and extent of the change. No such change had taken place through 1974, as the species of insects present were the same as collected before herbicidal spraying and the numbers of insects/sample also were comparable.

The figures for weight of insects/sample also were quite variable (Table 18). The factors previously discussed would, of course, apply to the weight figures. If the long-term effects of the vegetation change cause the amount of insects on the sprayed transects to change drastically, comparisons of weight/sample figures should indicate general trends.

Table 19 shows the results of the August 1971-74 grasshopper counts. Grasshopper numbers remained remarkably stable during the study, ranging from a mean low of 3.38/sq. yard to 4.58/sq. yard for all transects. A year by year summary of the number of grasshoppers/square yard on the spray and control transects is presented in Table 20. Grasshopper numbers dropped slightly on the spray transects in 1973, but numbers on the control transects also dropped proportionately. In 1974, the numbers/square yard on the spray transects rose slightly from 1973, while on the control transects they rose more than 1/square yard. This may indicate a reduction in the potential of the sprayed area to support grasshoppers, but the numbers are so similar that differences are not important insofar as the potential for supporting grasshoppers as food for juvenile blue grouse.

Fifty active ant mounds were marked with stakes on June 8, 1971. During the summer of 1971, 3 mounds became inactive and were replaced by active mounds. All 50 ant mounds were active through 1972. A check of the mounds was made on June 27, 1973. Forty-nine mounds were active then, and the remaining mound was not located. The mounds were checked again on June 6, 1974. The 49 mounds again were active and again the fiftieth mound was not located. The mounds were rechecked on September 28, 1974, and all but 6 were active. Those 6 may have appeared inactive because the cooler September weather caused the ants to go deeper into the ground and they were, therefore, harder to find. It is likely that most or all of these 6 mounds will be active in 1975. To date, herbicidal spraying has had no detectable detrimental effects on mound ants.

Mortality Factors. The mortality factors affecting both adult and juvenile blue grouse is an interesting question. Throughout the study, food and water appeared to be in abundant supply, making it hard to

Table 19. Grasshopper numbers/square yard on the control and spray transects during August of 1971-74.

Transect Number	GRASSHOPPERS/SQUARE YARD							
	August 11 1971	August 17 1971	August 10 1972	August 17 1972	August 10 1973	August 17 1973	August 15 1974	August 22 1974
Spray Transects								
1	3.25(1.62)*	3.00(1.62)	4.50(2.36)	4.60(2.23)	3.50(1.96)	3.00(1.63)	6.25(3.76)	2.75(2.16)
2	4.50(2.34)	5.25(1.89)	6.00(2.72)	4.75(2.57)	4.00(1.84)	3.50(1.67)	6.00(2.95)	4.00(2.23)
5	5.00(2.07)	6.00(2.07)	4.75(2.12)	5.00(2.46)	2.75(1.90)	3.25(1.80)	4.25(2.55)	3.50(2.33)
6	5.62(2.52)	5.25(1.98)	4.25(1.85)	5.00(2.24)	4.25(1.85)	6.50(3.54)	2.50(1.87)	3.00(2.30)
Control Transects								
3	6.25(2.70)	4.25(2.16)	3.00(1.63)	3.90(1.78)	4.25(2.36)	2.75(1.59)	4.25(2.47)	3.50(2.10)
4	2.50(1.35)	1.75(1.26)	3.00(2.06)	3.75(2.11)	1.50(1.15)	2.50(1.39)	4.25(1.73)	3.50(2.10)
All Transects	4.52(0.90)	4.25(0.72)	4.25(0.85)	4.38(0.88)	3.38(0.75)	3.58(0.68)	4.58(1.03)	3.38(0.86)

*The figure in parentheses is the 95 percent confidence interval for the mean.

Table 20. Year-by-year summary of grasshopper numbers/square yard on the spray and control transects, 1971-74.

Year	Grasshoppers/Square Yard in August	
	Spray Transects	Control Transects
1971	4.73	3.68
1972	4.86	3.41
1973	3.84	2.75
1974	4.03	3.88

imagine either being a limiting factor. Predation is a possible cause for some mortality. During 1970-72, blue grouse carcasses occasionally were found, always in too decayed a state to determine the cause of death. In 1973, however, 3 predator-killed blue grouse and 1 predator-killed sage grouse were found. The blue grouse were: 1 adult male, 1 male (probably a yearling), and 1 egg-laying female. The sage grouse apparently was a female. The female blue grouse and sage grouse, judging from the evidence at hand, were both killed by raptors. Evidence was insufficient to determine what killed the 2 male blue grouse. Only piles of feathers remained. The number of predator-killed grouse found in 1973 possibly indicates an increase over previous years. Two factors may have affected this increase. First, and perhaps the most likely, is that the late winter in 1973 caused a delay in the development of foliage on deciduous vegetation which provided cover for the grouse, particularly maple trees. In 1973, cover conditions were poor throughout April and most of May. This may have led to increased predation. The second possible cause was the 1972 herbicide spray, which killed and defoliated the sagebrush on many parts of the study area. All of the 3 dead blue grouse, however, were found in areas not greatly affected by the herbicide spray. This causes doubt as to the loss of sagebrush cover being a factor in the 1973 blue grouse predation. However, increased predation due to cover loss by spraying is a possibility. One predator-killed blue grouse was found in 1974. It consisted of a pile of feathers and was not on a sprayed area. A female, which was captured and tagged on June 6, 1974, while incubating, disappeared soon afterward. Since our experience with other nesting hens indicated that they do not desert easily, this female may have been preyed upon. The location of her nest had not been sprayed.

As mentioned previously, one blue grouse nest was destroyed by a mammalian predator in 1973. This nest was constructed under a sagebrush bush which had been killed by the 1972 herbicide treatment and offered little cover.

Disease is a third possible cause of mortality, although no abnormalities were found in 10 blood smears taken from juvenile blue grouse in 1971. No blue grouse were observed which appeared to be sick or abnormal in any way. However, 2 dead juveniles were found which had no marks of predation or other evidence of cause of death. It is assumed that these birds died from a disease or some other physiological problem. One was found on July 2, 1971, and was 2-3 weeks old. The other was located on July 27, 1973, and was 5 weeks old. The second grouse's crop was stuffed with grasshoppers.

Generally the summer weather on the study area was mild, with only occasional precipitation. On June 17-18, 1973, however, the temperature dropped to near or below freezing at night and some snow occurred, but did not accumulate. Since some of the blue grouse nests had hatched at that time, it was feared that there might be some chick mortality due to severe weather. Since the July 1973 brood size figures were comparable to previous years, however, this apparently was not the case. Zwickel (1967) observed 2 broods of blue grouse during severe weather in British Columbia and concluded that the chicks

were capable of surviving all but the most extreme weather conditions if the hen was available for brooding.

Effects of Grazing. Technically, cattle grazing was not allowed on the study area. However, cattle from nearby grazing allotments used the area for varying periods of time during each year of the study. Unfortunately, the cattle preferred locations also preferred by blue grouse broods. The cattle trampled and matted much vegetation in the aspen grove frequented by broods, considerably reducing the quality of the cover. Vann Covington reported in 1974 that cattle trampled much cover around water sources frequently used by broods. It would seem advisable to limit grazing to low levels in good blue grouse brood habitat or to delay the start of grazing until late in the summer when broods are beginning to leave the area. Sheep commonly grazed the area immediately to the east of the study area. In comparing the sheep-grazed range with the study area, it was apparent that there was more bare ground and less cover on the range grazed by sheep than on the study area. Trampling of nests by cattle or sheep is another possibility, if grazing is allowed on breeding areas before July.

Effects of Human Disturbance. Although several researchers carried on rather intensive work on the study area for 5 years, we detected no change in the behavior of the grouse which might have been caused by our work. One possible source of disturbance which may cause problems, however, is the off-road use of the area by 4-wheel drive vehicles. Since the study began in 1970, at least 2 new "roads" have been started by 4-wheel drive vehicles. One of these cuts across an area used by displaying territorial males. Another was created up the side of a steep slope, which already had destroyed some good nesting cover and will cause future erosion problems. Posting of signs and possibly better enforcement of vehicle laws might help alleviate this problem.

The rather rough road which traverses the study area receives a surprising amount of traffic in the summer from fishermen, motorbikers, sightseers, and even commuters. If it were ever paved or improved, the volume of traffic and people on the study area would increase drastically, possibly to the detriment of the breeding blue grouse. Efforts to pave the road should be discouraged.

EFFECTS OF HERBICIDE SPRAYING

Male territories. As long as herbicide spraying is not done near the edges of tree or tall shrub cover, the only male territories which probably will be disturbed are those located in stands of big sagebrush away from tree cover. Territories located in sage patches, which have been killed, probably will be deserted when the cover provided by dead sage branches decreases beyond an undetermined point.

Nesting areas. Since big sagebrush was used for nesting cover on the study area, sagebrush spray projects in blue grouse range may be detrimental to nesting cover. In areas such as the study area where most of the sage is low black sagebrush and there are only scattered patches of taller big sagebrush, the black sagebrush probably can be sprayed without much harm to nesting habitat, but spraying patches of big sagebrush or spraying any sagebrush close to woody cover probably will reduce nesting habitat.

Brood-rearing areas. Because broods generally remain close to woody cover and feed in adjacent open areas, any herbicide treatment of mule ears next to escape cover will reduce the amount of good brood habitat. Spraying, which thins out thick stands of mule ears, reduces their value as feeding cover for the broods. Since the mule ears vegetation type on the study area currently harbors a good population of grasshoppers, any change in this type might reduce the number of grasshoppers available to juvenile grouse. However, this did not happen during the present, short-term study. I feel that herbicide spraying of the study area had little, if any, detrimental or beneficial effects on brood-rearing habitat, except for a few small areas where spraying was done too close to woody cover, killing a few trees and thinning out some good brood cover.

General habitat requirements. With the exception of some big sagebrush patches which were ruined as nesting and male territory habitat by spraying, I feel the effects of the 2 herbicide treatments on the study area's blue grouse population have been negligible. Most of the area which was sprayed, was used littly by blue grouse for any purpose. If big sagebrush patches had been spared from spraying, I believe there would have been no detrimental effects upon blue grouse from spraying. Indeed, perhaps breaking up the uniform mule ears-black sagebrush vegetation type would improve the area as general wildlife habitat, by creating more vegetation diversity.

RECOMMENDATIONS

The following recommendations encompass both herbicidal spraying and other habitat manipulation techniques. It should be noted that blue grouse breed in habitats which vary widely in vegetation types, elevation, and topography. It is, therefore, difficult to provide blanket recommendations which will apply to all areas. I have tried to include recommendations which will apply to most blue grouse

breeding habitat in the central Rocky Mountain area, as well as more specific recommendations dealing with the breeding habitat type on the study area.

Size and design of herbicidal spray projects. It is assumed that any herbicide application will be for the purpose of reducing either mule ears or sagebrush or both, as was the case in the present study. If the target species is mule ears and little sagebrush is present, the primary consideration is the preservation of brood feeding cover around woody cover and near waterways. Large, open stands of mule ears located away from other cover species or wetland areas may be sprayed with little danger of significantly harming brood habitat. It seems both unnecessary and undesirable to attempt to remove 100% of the mule ears. Since diversity in vegetation generally is desireable for wildlife, it would seem best to either spray large expanses of mule ears in an irregular pattern or use a weak concentration of the herbicide and spray the entire stand, thereby not killing all of the mule ears. I recommend that no herbicidal spraying be done within 50 yards of any woody cover, such as islands of trees or tall shrubs like chokecherry. This cover is essential for broods, and the area immediately around it is important for feeding territories. At least a 30-yard wide buffer zone should be left unsprayed along streams and around seeps or springs. It also is recommended that "travel lanes" of unsprayed mule ears be left connecting woody cover with sources of water. These will afford broods with cover in traveling to and from water sources, if they need to do so. The travel lanes should be at least 20 yards wide.

If the spray target species is sagebrush, with no or only minor amounts of mule ears present, the preservation of brood habitat, nesting habitat, and possible male territories should be the concern. In the absence of mule ears, other taller forbs, or tall grasses, sagebrush takes on added importance as brood cover for feeding. Big sagebrush likely will be used as nesting cover by blue grouse hens, and some male territories may be located in big sagebrush patches. If the primary sagebrush to be sprayed is the shorter black sagebrush, with scattered patches of big sagebrush, none of the big sagebrush should be sprayed and at least a 20-yard buffer zone should be left unsprayed around islands of big sage. The 50-yard buffer zone should be left unsprayed around islands of big sage. The 50-yard buffer zone around woody cover recommended in mule ears ranges also is appropriate for sagebrush ranges. Large expanses of the short black sagebrush are of little value to blue grouse, but again it seems wise not to kill all of the sage in order to maintain habitat diversity. Spraying in irregular patterns or low concentration herbicide spraying again is recommended. Large expanses of big sagebrush present a problem, because it may be hard to determine what parts of the stand, if any, are used for nesting or male territories. If practical, it would be desirable to have a reconaissance of the area made in search of blue grouse, droppings, or dusting bowls. Areas with signs of blue grouse activity should be left unsprayed. In general, when spraying large stands of big sagebrush, the following should be left unsprayed (in addition to the buffer zones

already mentioned): 1) sagebrush along water courses or around seeps should not be sprayed within 30 yards of water; 2) travel lanes, at least 20-yards wide, from woody cover to water sources should be left unsprayed; 3) big sagebrush along the edges of ridges or dropoffs in the topography should be left unsprayed for 20 yards down the slope and 20 yards back from the edge. This is especially important for dropoffs which face south, as these areas are the best locations for nests or territories.

It theoretically would be possible to create new male territory habitat in dense stands of big sagebrush. Territories found away from trees were all in stands of big sagebrush, surrounded by shorter vegetation. Probably the reason why male territories would not be located in large stands of big sagebrush is that there would be no open areas available for displaying. By leaving a patch of big sagebrush of about an acre in size and spraying the sagebrush around it, an island of cover surrounded by open vegetation would be created, and possibly used for male territories. This, of course, is conjecture, but needs to be evaluated as a habitat improvement procedure.

All of the recommendations for spraying sagebrush on blue grouse ranges are made on the assumption that no sage grouse are present. With sage grouse also on the area, which is a likely possibility, additional precautions should be taken.

Protection and enhancement of male territories. The following are recommended:

1) No herbicide spraying within 50 yards of woody cover.

2) Create possible new territory locations in big sagebrush stands (as previously described), by spraying surrounding vegetation and leaving an island of about an acre in size.

3) Open thick vegetation by selective timber cutting or brush removal, especially on south-facing slopes, thereby perhaps creating new territory locations.

4) Planting of trees (aspen, maple, and especially juniper) to break up low, open vegetation will create new territory sites.

Protection and enhancement of nesting areas. The following are recommended.

1) No herbicide spraying within 50 yards of woody cover.

2) Leave unsprayed islands of big sagebrush which occur among short, black sagebrush or other low vegetation.

3) Do not herbicidally treat big sagebrush within 20 yards of a ridge edge or dropoff in the topography, especially if it is south facing.

4) Encourage big sagebrush by protection or introduction, if necessary, along the edges of tree cover in areas where it does not occur and where other nesting cover appears sparse.

5) Prohibit or allow cattle and sheep grazing only at low numbers during the nesting season (May-June) to avoid nest trampling and hen harassment.

6) Maintain good range conditions through proper grazing rates to maintain ground cover and food plants for nesting females.

Protection and enhancement of brood-rearing areas. The following are recommended:

1) No herbicide spraying within 50 yards of woody cover.

2) Leave unsprayed buffer strips at least 30-yards wide along streams and around seeps or springs. Provide "travel lanes" at least 20 yards wide by leaving unsprayed areas between woody cover and water sources.

3) Develop new water sources to provide better cover, more insects, and free water to encourage more complete utilization of potential habitat.

4) Maintain good range conditions through proper stocking rates. Where possible, limit grazing during the first portion of the brood season (until August). Fence water sources to reduce trampling of the surrounding cover by livestock.

5) Plantings of fruit-producing shrubs (serviceberry, chokecherry, snowberry, and wild rose) will provide additional food sources for juvenile grouse, especially in the latter part of the summer, and will provide additional food sources if there is a year of low insect availability.

6) Plantings or encouragement by protection of tree species (especially maple) to break up open areas of low vegetation will create new brood habitat.

It also is recommended that a followup study be made of the study area during the late 1970's to determine the long-term effects of vegetational changes upon blue grouse.

SUMMARY

HABITAT REQUIREMENTS

Male Territories. The necessary components of a male territory are: 1) escape cover - which may consist of tree cover (aspen, juniper, maple, Gambel's oak, or curlleaf mahogany in the case of the present study area) or shrubs (big sagebrush, snowberry, or serviceberry).

2) openness - is necessary so that the displaying male may be viewed by females. Sparsely spaced tree cover will frequently be used, especially if shrubs such as sagebrush are also present. Some territories may be made up partially of dense thickets or shrubs, but in such cases they will border open areas. The males will spend most of their time in the cover and display in the open.

3) food - territorial male blue grouse subsist on flowers, leaves and buds. An adequate supply of food should be on or near the territory. It is not known if a territorial male will leave his territory to feed. Free water probably is not needed, if an adequate supply of vegetation is available.

4) accessibility - some areas which otherwise might be suitable for territories are covered with snow well into the breeding season. For this reason, few territories are on north-facing slopes.

Nesting Areas. The primary consideration in nest site selection is concealment. Almost all nests located were well concealed from view from the sides, above, or both. None of the nests were located under tree cover, possibly to allow the sun to reach and warm the nest or possibly to allow the hen to view the surrounding area. On the study area, big sagebrush was by far the preferred plant chosen as nesting cover. Many blue grouse breeding ranges are located where no sagebrush occurs. Thus, alternate cover obviously is used in these areas for nesting; but if big sagebrush occurs on a blue grouse breeding range, it likely is used for nesting. Nesting females eat mainly plant food, including various flowers and leaves. It is likely that nests are chosen so that adequate food supplies are nearby. It is not known if nesting females need free water. Although no grouse were observed to drink, most nests on the study area were located near water.

Brood-rearing Areas. Habitat requirements for brood-rearing areas include: 1) escape cover - broods seldom moved far from woody cover, usually aspen, maple, juniper, or curlleaf mahogany. Maples seemed to be preferred over other tree species, because they had more branches close to the ground which provided good concealment.

2) feeding cover - most feeding took place in mule ears and black sage cover which generally was 12-15 inches in height and provided good concealment for broods. It was difficult to see broods moving through stands of thick mule ears.

3) food - juvenile blue grouse subsist primarily on an insect diet for the first 2 months of life. Grasshoppers were by far the most important food item for grouse on the study area, but other insects and plant foods will be taken in areas where grasshoppers are less abundant. Vegetation types which harbor few insects likely will be poor brood-rearing habitat.

4) wet areas - while probably not absolutely necessary, wet areas add to the quality of brood-rearing habitat, because they support lush vegetation which harbors many insects. In extremely dry summers, free water may be needed.

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Appendix A

Table 21. Percent occurrence of the less common plant species occurring on both spray and control portions of the study area (combined), 1971-74.

Plant Species	MAY				JUNE				JULY			
	1971	1972	1973	1974	1971	1972	1973	1974	1971	1972	1973	1974
FORBS												
Anaphalis margaritacea	--	--	--	--	0.4	--	--	--	--	--	--	--
Antennaria rosea	--	0.4	--	--	--	0.4	--	--	--	0.8	--	--
Arabis spp.	7.1	8.0	3.3	1.3	2.9	2.0	2.9	0.4	0.8	3.0	1.2	--
Arenaria kingii	--	2.0	--	--	--	4.0	--	--	--	3.0	--	--
Astragalus spp.	1.2	2.0	0.4	--	3.3	3.0	1.7	0.4	2.1	3.0	2.1	0.8
Cammassia quamash	7.5	6.0	6.3	--	5.0	8.0	5.0	6.6	1.2	1.0	3.3	0.8
Camelina microcarpa	--	--	--	--	0.8	--	--	--	--	--	--	--
Collomia tenella	--	--	--	--	10.4	--	--	--	--	--	--	--
Delphinium nelsoni	--	7.0	20.4	9.2	5.8	4.0	4.2	4.6	--	--	0.4	--
Dicentra uniflora	0.4	--	--	--	--	--	--	--	--	--	--	--
Dodecatheon spp.	--	--	--	--	--	--	--	--	0.4	--	--	--
Eriogonum umbellatum	--	--	--	--	--	1.0	--	--	--	1.0	--	--
Erythronium grandiflorum	2.9	1.0	0.4	0.4	1.7	1.0	--	0.4	--	--	0.4	--
Frittileria pudica	0.8	2.0	1.7	--	--	--	0.4	--	--	--	--	--
Galium aparine	--	--	--	--	14.2	--	9.2	--	0.8	--	--	--
Geranium fremontii	--	--	0.8	0.8	0.4	1.0	0.4	0.4	0.8	0.4	0.8	1.7
Grindelia squarrosa	--	--	--	--	1.7	4.0	3.3	6.3	5.8	2.0	4.6	5.0
Hydrophyllum capitatum	2.5	5.0	5.0	2.9	1.7	1.0	1.2	2.9	--	--	--	--
Lactuca serriola	--	--	--	--	--	--	0.4	--	--	--	--	--
Lewisia pygmaea	--	--	--	--	0.4	--	--	--	--	--	--	--
Lomatium gravi	1.2	3.0	5.0	--	2.1	3.0	2.9	3.3	0.8	0.8	--	0.4
Lomatium simplex	--	9.0	--	8.3	--	7.0	--	4.6	--	--	0.4	4.2
Navarretia intertexta	--	--	--	--	5.8	6.0	8.8	5.8	14.2	5.0	4.2	5.8
Orogenia linearifolia	--	3.0	17.9	0.4	--	1.0	--	--	--	--	--	--
Orthocarpus purpureoalbus	--	--	--	--	--	--	--	--	10.4	--	--	--
Penstemon spp.	0.8	--	--	--	4.6	--	--	--	1.2	--	--	--
Polemonium spp.	7.1	--	8.3	--	3.3	1.0	4.6	--	2.5	1.0	0.8	--
Sagina saginoides	--	--	--	--	--	--	--	--	3.3	--	--	--

Table 21. (continued)

Plant Species	MAY				JUNE				JULY			
	1971	1972	1973	1974	1971	1972	1973	1974	1971	1972	1973	1974
Taraxacum spp.	--	1.0	--	--	0.8	1.0	--	--	--	--	--	--
Thlaspia spp.	--	1.0	--	--	--	2.0	--	--	--	2.0	--	--
Tragopogon spp.	--	--	--	--	--	1.0	--	--	--	--	--	--
Trifolium spp.	--	--	--	--	--	0.4	--	--	--	--	--	--
Veronica campylopoda	--	--	--	--	9.2	4.0	5.0	--	0.4	--	--	--
Zigadenus paniculatus	4.6	7.0	2.9	12.1	5.0	7.0	5.0	6.3	0.8	1.0	--	0.8
GRASSES AND GRASSLIKE												
Carex spp.	2.1	1.0	--	--	1.7	0.4	0.8	--	1.7	3.0	1.7	--
Danthonia spp.	0.4	--	--	--	10.8	5.0	3.8	--	12.1	12.0	1.7	--
Hordeum jubatum	--	--	--	--	--	--	--	--	2.9	--	4.2	--
Koeleria cristata	--	--	--	8.8	0.8	1.0	6.3	12.1	3.8	6.0	10.0	15.0
Melica bulbosa	0.4	--	--	--	10.4	5.0	15.4	21.2	8.7	10.0	17.1	12.9
SHRUBS												
Artemisia tridentata	0.4	1.0	--	--	--	--	--	--	--	--	--	--
Berberis repens	--	--	--	--	--	--	--	--	--	1.0	--	--
Symphoricarpos oreophilus	--	--	--	--	--	0.4	--	--	--	--	--	--

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